BULLETIN No. 13.

Department of Agriculture,
Gold Coast.

YEAR-BOOK
1927.

Issued by
The Honourable the Director of Agriculture.

DEPARTMENT OF AGRICULTURE, GOLD COAST.

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PAPER No. I.

DEPARTMENT OF AGRICULTURE AND AGRICULTURAL INDUSTRIES, 1927.

By Hon. C. H. KNOWLES,
Director of Agriculture.

Cacao.

During the year just completed the amount of cacao exported has shown a fall, thus breaking the series of record crops which had succeeded one another for some years. This, however, must not be taken to indicate any serious set-back to the industry.

The crop of individual trees varies very much year by year, but this individual variation is practically obliterated by considering crops over a large enough area, since the variations year by year are due more to those local fluctuations in climatic conditions which are the basis of variations of agricultural crops in all countries. A paper in the Yearbook indicates some correlation between rainfall and crop, and this is an investigation which is being continued.

Another factor which is of great importance in this country is that the crop figures are the exports from the country. Taken over a few years they are reliable as a measure of the crops, but in comparing one year with another, they are liable to be misleading, being affected by such artificial factors as the withholding of the produce from the market by the grower or the exporter, and the shortage of transport facilities by land or sea.

The drop in the crop compared with last year is some 10 per cent., which, even if due to purely natural causes, cannot be taken to be in any way excessive.

Prices during the year have been very good.

Sanitation.

The work under the Cacao Sanitation Scheme was reorganised during the year, whereby the Department's first duty is confined to giving demonstrations of efficient methods in each village or other suitable centre, after which the farmers are required to apply the methods to their farms should the diseases requiring such treatment be present. The cultural side of cacao farming is being emphasised by the Inspectors, who also include references to the necessity for proper fermentation of the produce and complete drying.

In the event of the advice not being taken, the duty of clearing away diseased material then falls on the Government.

Manurial Experiments.

The manurial tests on cacao have shown very great initial variations in the plots, which have to be fully determined before the effects of the manures be known.

Some interesting figures will be found on the subject of individual yields of cacao trees. The total number of individual trees investigated was over 300 at the beginning.

Port Inspection.

The inspection of cacao at ports was commenced on January 1st, 1927, and has been continued throughout the year, and much invaluable information has been outlined. Thanks are due to the exporters for their unanimous consent to submitting their exports to sampling for this examination.

The papers included in this Yearbook cover only the methods and errors in sampling. The information obtained by the actual inspection is submitted to the shippers concerned.

Other work described in the papers includes investigations carried out into the causes of certain of the defects of cacao beans, and also into certain pests and diseases.

Coconuts.

The palms at the Atuabo coconut plot began to come into bearing in quantity during the year. The plantation was duly equipped with a dryer for using artificial heat. The paper given shows the results with the dryer, which are not so good as may be expected after the present accumulated crop containing many germinated nuts is worked off.

Now that actual sales of copra are being made, the people in the neighbourhood are taking more interest in the crop.

Sisal Hemp.

The plantation has not had a successful year, since a lengthy stoppage had to be made in the working of the mill on account of leaf shortage.

During the working time, the results as to production and costs were quite near the average.

Cotton.

The ginnery at Tamale has been completed, but the results from the first distribution of cotton seed were not good. The people simply did not use the seed. The reasons are, however, known, and as they are in no way an agricultural problem, they are being dealt with, by the officers concerned.

There seem no purely agricultural reasons (as regards soil, climate or the knowledge or ability of the people) why the crop should not succeed.

The Department has initiated tests with seed imported from Nigeria against that used by the people from time immemorial, and it is a pleasing indication that the people have recognised the superiority of the distributed seed. Plots have been laid down for the purpose of increasing this superiority by the selection of suitable plants, and their propagation in succeeding years in order to establish a type specially suited to Northern Territories, in the same way as has been done in Nigeria.

Limes.

The Lime area is now regarded as complete, and all that remains in order to establish the beginning of the lime-juice industry, is the building and operation of the mill referred to last year.

Conferences.

The Department was represented at the First West African Agricultural Conference held at Ibadan, Nigeria, in March, the First International Soil Congress, held at Washington in July, and the First Imperial Agricultural Research Conference, held in London in October, 1927.

Résumés of the first and last are given in these notes. In regard to the second, some delay has taken place in the publication of the complete range of resolutions which were passed, hence a note on the Congress is being held back until the 1928 Yearbook.

Organisation.

The agricultural policy of the Government and the organisation of the Department have been the subject of consideration by a Departmental Committee which sat from April to July. The Report of this Committee is now being considered by Government.

PAPER No. II.

REPORT ON THE IMPERIAL AGRICULTURAL RESEARCH CONFERENCE, 1927.

(*The delegates from the Department of Agriculture of the Gold Coast to the Conference were* G. G. AUCHINLECK, R. H. BUNTING, W. H. PATTERSON, *and* A. C. MILES.—*Editor.*)

2. Diary.

The following meetings were attended, and visits made, by one or more of the delegates.

29th September.—Meeting of Colonial delegates with Lord Lovat's Committee on Agricultural Research and Administration.

4th to 7th October.—Daily plenary sessions of Conference for preliminary consideration of administrative and technical questions, and appointment of an administrative commission, and technical committees, to discuss questions in detail.

10th to 13th October.—Meetings of the Plant Pathology, Plant Breeding, Entomology, Agricultural Economics, Committees, and a combined meeting of the Fruit, Plant Pathology, and Entomology committees.

14th October.—Visit to the National Institute of Agricultural Botany, Cambridge.

15th October.—Visit to the Animal Nutrition Institute, Plant Breeding Institute, School of Forestry, and University farm, Cambridge.

16th October.—Visit to the Botanical Gardens, Cambridge.

17th October.—Visit to the Bio-Chemical Laboratory, Low Temperature Research Institute, Molteno Institute of Parasitology, Balfour Institute of Genetics, Departments of Botany and Zoology, Cambridge.

18th October.—Visit to Messrs. Chivers, jam factory, Histon.

19th October.—Visit to the Imperial Chemical Works, Billingham.

20th October.—Visit to the Department of Botany, Edinburgh University.

21st October.—Visit to the Scottish Plant Breeding Station, and the Plant Registration Station, Corstorphine.

22nd October.—Visit to Messrs. Gracey Bros.' Cold Store, Belfast; the Northern Ireland Plant Breeding Station and Animal Diseases Research Station, Stormont; and the Linen Research Institute, Lambeg.

26th to 28th October.—Daily plenary sessions of Conference to consider reports of administrative commission, and technical committees. Meeting of Economic Botanists.

29th October.—Visit to the Rothamsted Experimental Station, Harpenden.

30th October.—Visit to the Imperial Institute, and Royal Horticultural Society Gardens, Wisley.

31st October.—Visit to the Imperial College of Science (Plant Physiology Research Institute), South Kensington; the Royal Botanic Gardens, Kew; and Imperial Institute.

1st November.—Visit to the East Malling Research Institute.

2nd/3rd November.—Visits to the North Wales University College, Bangor, and the John Innes Horticultural Institute, Merton.

4th November.—Visit to the Agricultural and Horticultural Research Station, Long Ashton, Bristol.

7th November.—Meeting of West African Delegates with Major Elliot of the Empire Marketing Board.

3. Composition of Conference.

The personnel of the Conference consisted of nearly 200 members from all parts of the Empire, and included representatives of the Colonial and Dominions Offices, Ministries of Agriculture for Britain and Northern Ireland, Scottish Board of Agriculture, Agricultural and Medical Research Councils, Imperial Bureaux of Entomology and Mycology, Empire Marketing Board, Department of Overseas Trade, Board of Education, Imperial Institute, Royal Botanic Gardens (Kew), Royal Agricultural Society of England, Empire Cotton Growing Corporation, Linen Industry Research Association, etc.

Lord Bledisloe, of the Ministry of Agriculture and Fisheries, was appointed Chairman.

4. Benefits Derived.

It will be readily understood from the representative composition of the Conference that, apart from the future benefits which may be expected to result from the business enacted at the formal meetings, much inspiration and beneficial knowledge was gained by informal conversations with workers from the varied countries represented, as well as from contact with those in administrative authority at home. There are also to be recorded the no less valuable stimuli and knowledge gained by visits to the various British research centres, where, by demonstrations and technical addresses, something was learnt of results achieved and of work in progress, in all the diverse and minute branches of the agricultural sciences.

The Conference concerned itself chiefly with the consideration of fundamental research, such as is intended to result in long-range, rather than local, application. For those whose work is restricted to the advisory and "general practitioners'" provinces of agricultural science, the broadening effect of such an aspect was particularly gratifying.

5. Administrative Recommendations.

The Conference, being in no way an executive body, could not do more than formulate advice and recommendations to the Governments concerned. Briefly stated, the recommendations made on administrative questions were as follows:—

i. Establishment of Central Research Stations in Tropical and Sub-Tropical Countries.—The following provisional programme for the establishment of new Central Research Stations was recommended, subject to modification by the proposed Colonial Agricultural Council, and in addition to those already established at the Imperial College of Tropical Agriculture, Trinidad; and at Amani, East Africa, and to that proposed by the Australian Government for North Queensland:—

Ceylon, probably for tea and rubber research.
East Africa, probably for animal diseases.
West Africa, probably for vegetable oils, oil seeds and nuts.
Federated Malay State (or Middle East), probably for coconuts and oil palms, irrigation, and veterinary research.

It was recommended that the proposed stations should (1) satisfy Imperial rather than local requirements; (2) confine themselves to long-range and wide-range research, *i.e.*, to problems requiring prolonged investigation, and to those problems which arise in more than one territory; (3) deal individually with particular fields of agriculture, rather than that they should be instituted for geographical reasons; (4) reinforce, but in no way substitute, the proper scientific work of local Departments of Agriculture; and (5) that they should not undertake teaching work.

ii. Recruitment and Training of Officers.—The Conference considered that a unified system of recruitment and training for agricultural and scientific officers for the whole of the Empire was impracticable; the following conclusions and recommendations under these heads were therefore made for the Colonial service :—(1) that the dearth of recruits made immediate reinforcement in recruitment and training essential; (2) that the standard required for (*a*) specialist officers be an honours training in the pure sciences, including at least one biological science, and an adequate knowledge of agriculture; and for (b) agricultural officers, wide agricultural knowledge, a practical outlook, administrative ability, and sufficient scientific knowledge for the full utilisation of scientific results, and for collaboration with specialist officers; (3) that character and health be considered of first importance; (4) that adequate emoluments, facilities for work, and satisfactory superannuation arrangements were necessary for purposes of recruitment and efficiency; (5) that the Colonial Office Agricultural Scholarship Scheme, if strengthened and suitably modified to include veterinary science, might be expected to meet Colonial requirements for the present.

iii. Study-Leave and Interchange of Officers.—The Conference came to the following conclusions :—

(1) that facilities of study-leave for officers were essential to the success of the agricultural service;

(2) that "existing facilities for study-leave are, in general, inadequate," and that "specific financial provision, and appropriate increases in staff to make study-leave possible, are an urgent necessity";

(3) that a routine interchange of officers was to be deprecated, but that occasional interchange would bring many benefits; and

(4) that existing facilities for the beneficial interchange of workers were inadequate, mainly because of financial difficulties.

iv. Establishment of Bureaux and Correspondence Centres.—The establishment of the following as new imperial bureaux on the lines of those existing for entomology and mycology was recommended :—

(1) Soil science, to be attached to the Rothamsted Station.

(2) Animal nutrition, to be attached to the Rowett Institute, Aberdeen.

(3) Animal health, for immediate establishment in London.

In addition to the above bureaux, it was recommended that clearing stations of information, to be termed correspondence centres, should be established for the following subjects :—

(1) Animal genetics, to be attached to the University of Edinburgh.

(2) Agricultural parasitology, to be attached to the Institute of Agricultural Parasitology, London School of Hygiene and Tropical Medicine.

(3) Plant genetics for herbage plants, to be attached to the Welsh Plant Breeding Station, Aberystwyth, and for other crops, to the Cambridge University.

(4) Fruit production, to be attached to the Research Station, East Malling.

N.B.—The functions of a correspondence centre are intended to be the collection, collation, and dissemination of information of a scientific and technical character, to reply to enquiries on scientific and technical problems, and particularly to facilitate intercourse among workers.

The Conference considered that the establishment of a bureau of general agricultural research was not practicable, and that the time would not be ripe for the establishment of either bureaux or correspondence centres on any other subjects than the above, until such subjects were sufficiently defined.

The Conference further recommended that (1) the funds made available for the establishment of the proposed bureaux and correspondence centres should be administered by an Authority representative of the contributing Governments; (2) each bureau should be administered by a technical committee of experts nominated by the Governments concerned, and that (3) each correspondence centre should, as far as practicable, be conducted similarly.

v. Conferences of Research Workers.—It was decided that the next Imperial Agricultural Research Conference be held in Australia in 1932, and it was recommended that specialist and regional conferences should be held at fairly frequent intervals.

6. Technical Recommendations.

The Conference agreed *nem. com.* to support the following recommendations and suggestions proposed by the technical committees:—

i. Plant pathology and mycology:—

(1) that the reports already submitted each month appeared to be all that was necessary to meet the demand of the International Institute of Agriculture at Rome for early official notification of plant diseases and pests;

(2) that lists of plant diseases occurring in each country of the Empire be prepared, and revised when necessary, by Governments concerned and published and distributed by the Imperial Bureau of Mycology;

(3) that, with a view to uniformity in plant disease nomenclature, the attention of Empire mycologists be called to the list of plant disease names now under preparation by the British Mycological Society, and that the Society should circulate the list to all Governments of the Empire;

(4) that the Imperial Bureau of Mycology be asked to prepare, and when necessary to revise, a list of books and periodicals to be regarded as the minimum requirements for a Government Mycologist, and that a copy of the list be forwarded to the departments concerned;

(5) that overseas Governments supply copies of all officially published papers and bulletins on mycology and plant pathology to Institutions mentioned in a list to be prepared by the Imperial Bureau of Mycology; and

(6) that, in view of the urgency of the problems of virus diseases, no time should be lost in the provision of funds for the more extended study of the nature of virus diseases in plants.

ii. Entomology:—

(1) that each entomological service in the Empire should be represented by an entomologist at the quinquennial entomological conferences, and that sufficient delegates should be sent from the larger entomological services to represent their various activities;

(2) that such conferences occasionally be held in other Imperial centres than London;

(3) that travelling fellowships be established for entomologists engaged on special lines of investigation;

(4) that the necessity of paying more attention to the biological control of insect pests should be emphasised, as well as the need of giving further assistance to the parasite work of the Imperial Bureau of Entomology; and

(5) that the importance of training and research in pure entomology should be emphasised.

iii. Fungicides and insecticides :—

(1) that an investigation of the whole chemical field should be undertaken by chemists, in collaboration with entomologists and plant pathologists, in order to supplement the limited number and relatively inefficient substances at present used for control of diseases and pests.

iv. Fruit :—

(1) that the most urgent problems in fruit cultivation requiring research were (*a*) the study of stock and scion, and their inter-relation; (*b*) surveys of fruit areas to determine the relation of various factors to tree growth and fruitfulness; (*c*) chemical studies relating to the tree and its crop; and (*d*) the associated physiological studies.

(2) that, while much research work on these subjects had been done, such work should be greatly extended, and additional workers employed on these problems.

v. Preservation and transport :—

(1) that all parts of the Empire as well as Great Britain should undertake the solution of fundamental problems relating to the preservation and transport of agricultural produce, *e.g.*, tropical fruits;

(2) that the scientific, as distinct from the economic inspection of cargoes from overseas should properly be carried out by representatives of the country of origin, to whom the Department of Scientific and Industrial Research would lend their assistance; and

(3) that each research centre of the Empire should forward all its publications on the preservation and transport of food to the Low Temperature Research Station at Cambridge, which station should periodically publish and distribute lists of elaborated titles of useful publications on those subjects, and that the operation of such a scheme should be reviewed later.

vi. Soils and fertilisers :—

(1) that a memorandum on soil classification be circulated by the proposed bureau of soils, for the guidance of soil chemists throughout the Empire;

(2) that where soil survey data are to be published, the mechanical analysis of soils should be made by the International method, or by some other method which has been shown to give the same result, it being recognised that certain soil types require special methods, details of which methods should be worked out by the soil bureau for circulation;

(3) that the soil bureau should prepare and circulate a memorandum on the fundamental principles which should govern all fertiliser trials throughout the Empire; and

(4) that the soil bureau should prepare and circulate suitable suggestions for experimental work, and recommendations regarding soil deterioration due to shifting cultivation, disafforestation, etc.

vii. Agricultural economics :—

(1) that the necessity for a systematic and continuous study of economic conditions, as a means of promoting prosperity in Empire agriculture, should be emphasised;

(2) that the Governments of the Empire should secure the services of whole-time agricultural economists on the staffs of their Departments of Agriculture.

(3) that the attention of the Universities of the Empire should be directed to the dearth of technically trained workers in this field;

(4) that the principal methods of investigation in the economics of farm production should be (*a*) cost accounting, (*b*) farm surveys;

(5) that economic surveys should be considered as desirable, especially in the framing of agricultural policies with particular reference to the development of new areas;

(6) that among the chief objectives of marketing research should be (*a*) abolition of waste, and (*b*) the lessening of price fluctuations, for which objects continuous research is required in each country;

(7) that the collection of agricultural statistics should be attempted in all countries of the Empire where such is not already being done, and that, where necessary, Governments should assume the power to do so; and

(8) that all Governments of the Empire should co-operate to the fullest possible extent in the project of the World's Agricultural Census, 1930-31.

viii. Animal health, nutrition and genetics, and dairying.—The vast importance of these subjects to the Empire was agreed by the Conference, and recommendations were made chiefly for the closer co-operation of workers, and for the extension and increase of research work.

7.—

In general, it may be recorded that, throughout the meetings and visits, an atmosphere was constantly present which emphasised the unmistakable necessity for fundamental scientific research as a basis, not only for the improvement of production and its cognate subjects, but also for the economics of agriculture. Although this aspect may prove, in many of its details, to be at present too idealistic for local application, the Gold Coast may be expected to share in the benefits to be derived from the solidification of scientific effort throughout the Empire. The machinery set up by the Imperial Government, *e.g.*, The Empire Marketing Board, the proposed chain of research stations, the new bureaux, the periodical foregathering of workers from all parts of the Empire, demonstrate not only the recognition of the fundamental importance of agriculture, but also the desire for solidarity of effort within the Empire, and the prospect of mutual inter-imperial assistance.

PAPER No. III.

Resolutions passed by
THE FIRST WEST AFRICAN AGRICULTURAL CONFERENCE, 1927.

(*The delegates from the Department of Agriculture of the Gold Coast to the Conference were* G. G. AUCHINLECK, R. H. BUNTING, G. S. COTTERELL, R. COULL *and* A. W. PATERSON.) .

Origin.

The First West African Agricultural Conference was held from March 4th to 10th, 1927, at Moor Plantation, Ibadan, the headquarters of the Nigerian Department of Agriculture. In June, 1925, the Second Imperial Entomological Conference in London had passed a resolution recommending that periodical meetings of Entomologists, Mycologists and other scientific officers should be held in various Dominions and Colonies. The Governors of Nigeria, the Gold Coast, Sierra Leone and the Gambia decided to act on this resolution, on condition that the basis of the West African meeting was broadened so as to include all lines of work carried on by local Departments of Agriculture.

Aim.

The West African Conference has therefore come into line with Agricultural Conferences elsewhere, such as the West Indian, the Pan-Pacific, and the Imperial Agricultural Conferences. The main aim of such conferences must be the development of sound agricultural policy in the countries they serve, and the numerous specialist lines of work which are contributory to the general aim fall naturally into correct perspective if the general aim is kept in mind.

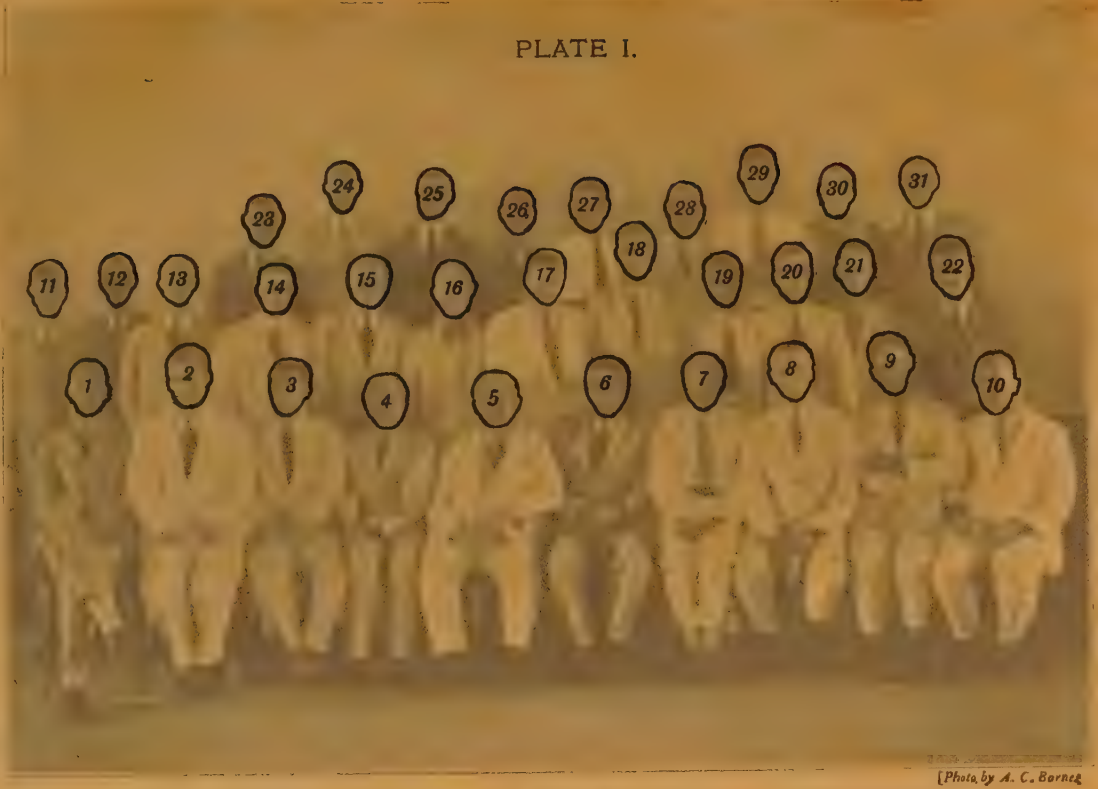
Papers Read.

Discussions at the West African Conference centred around the following papers which were prepared by delegates: —

1. *The Oil-palm Industry and its problems in Sierra Leone,* by Messrs M. T. Dawe and F. J. Martin.
2. *The Oil-palm Industry in Sumatra and Malaya,* by Messrs G. G. Auchinleck and H. B. Waters.
3. *The Extraction of Oil-palm Products,* by Mr. A. C. Barnes.
4. *The Grading of Cotton, Cocoa and Palm Products,* by Messrs. A. J. Findlay and E. McL. Watson.
5. *Some Aspects of the Gold Coast Cocoa Industry,* by Mr. A. W. Paterson.
6. *Diseases of Cocoa, and Measures for their Control,* by Mr. R. H. Bunting.
7. *Pests of Cocoa in the Gold Coast,* by Mr. G. S. Cotterell.

PLATE I.

1 F. J. MARTIN SL
2 A. C. BARNES N
3 E. M. WATSON N
4 T. LAYCOCK N
5 M. T. DAWE SL
6 O. T. FAULKNER (Chairman) N
7 G. G. AUCHINLECK GC
8 P. H. LAMB N
9 E. HARGREAVES SL
10 R. H. BUNTING GC
11 O. B. LEAN N
12 F. D. GOLDING N
13 H. ROEBUCK N
14 H. B. WATERS N
15 H. G. POYNTER N
16 B. BROWNE N



17 T. O'N. HEWITT N
18 A. W. PATERSON GC
19 G. H. JONES N
20 A. G. G. HILL N
21 O. S. SWAINSON N
22 G. S. COTTERELL GC
23 R. COULL GC
24 E. de B. DIAMOND N
25 R. V. D. WHITE N
26 T. THORNTON N
27 C. T. LEWIN N
28 C. H. WRIGHT N
29 T. R. V. SMYTHE N
30 F. C. DEIGHTON SL
31 S. H. GILBERT N

N = NIGERIA
GC = GOLD COAST
SL = SIERRA LEONE

[Photo by A. C. Barnes

FIRST WEST AFRICAN AGRICULTURAL CONFERENCE,
IBADAN, NIGERIA,
1927

FIRST WEST AFRICAN AGRICULTURAL CONFERENCE

IBADAN, NIGERIA,

1927

PLATE I

THE [illegible] AGRICULTURAL CONFERENCE

Aim.

Papers Read.

1 F. J. MARTIN SL
2 A. C. BARNES IN
3 E. M. WATSON IN
4 T. T. CAYCOCK IN
5 W. T. DAVIES SL
6 O. T. FAULKNER CC
7 C. C. CUSCHIERI CC
8 P. H. LAMB IN
9 E. HARGREAVES SL
10 R. H. BUNTING CC
11 O. BELL IN
12 D. D. CURTIS IN
13 H. ROBSON IN
14 H. B. WATERS IN
15 H. C. PROUTER IN
16 B. BOURNE IN

17 T. ON. HEWITT IN
18 A. W. PATERSON CC
19 C. H. JONES IN
20 A. C. HILL IN
21 O. S. SWANSON IN
22 C. S. COTTERELL IN
23 E. B. DIAMOND IN
24 R. V. D. WHITE IN
25 T. H. THORNTON IN
26 T. T. LEWIN IN
27 C. H. WRIGHT IN
28 T. R. V. SMYTHE IN
29 E. C. DEIGHTON SL
30 H. S. H. CILBERT IN
31 C. H. GILBERT IN
32 A. J. [illegible]
33 [illegible]
34 [illegible]
35 [illegible]

SS=SIERRA LEONE
CC=GOLD COAST
N=NIGERIA

8. *Some Insect Pests of Sierra Leone*, by Mr. E. Hargreaves.

9. *Nigerian Insect Pests of Cotton*, by Messrs. F. D. Golding and O. B. Leans.

10. *Fungoid Pests of Cotton*, by Messrs. T. Laycock and G. H. Jones.

11. *The Maintenance of Soil Fertility by Rotational Green Manuring*, by Messrs. A. G. G. Hill and H. B. Waters.

12. *Soil Investigations, Sierra Leone, with special reference to a Soil Survey of British West Africa*, by Messrs. F. J. Martin and H. C. Doyne.

These papers, together with the major outlines of discussion, have been printed by the Nigerian Government in a volume entitled " Proceedings of the First West African Agricultural Conference, Ibadan, 1927." Copies of the volume available at the office of the Director of Agriculture, Accra, Gold Coast.

Other Discussions.

A very full discussion took place on the future of the oil-palm industry and the likelihood of severe competition from the plantations which are being established in the East. Other debates dealt with the establishment of a West African Agricultural College, the collection and publication of accurate statistics of agriculture, and the fostering of trade with Canada, South Africa and the United States of America. The chemists present sat in committee and prepared the general outlines of a Soil-Survey of British West Africa, and the entomologists submitted proposals for systematic co-operation and exchange of information. Certain staff matters were also fully discussed.

Resultant Resolutions.

The following resolutions were passed by the Conference, to be submitted to the Governments concerned : —

RESOLUTION NO. 1.

That this Conference has duly considered the question of future Conferences, in regard to the frequency with which it would be convenient that it should be held and the Colonies in which it should in turn take place, and recommends :—

(*a*) That for the coming six years it be held biennially.

(*b*) That after that period it be held once in every three years.

(*c*) That it takes place in the other three Colonies (with the approval of the Governments concerned) in the following sequence :—in 1929 in the Gold Coast, in 1931 in Sierra Leone, and in 1933 in the Gambia.

"

RESOLUTION NO. 2.

That this Conference wishes to recommend that an Entomologist be sent to Fernando Po and St. Thome to investigate the reasons for the scarcity of Sahlbergella spp. in those islands, including the possibility of control by natural enemies.

RESOLUTION NO. 3.

(*a*) That co-operation should be established between the Entomologists of the three West African Departments of Agriculture represented at this Conference.

Co-operation would include such matters as :—

(i) Exchange of annual programmes of work prior to the commencement, and of summaries of results of recent work, before publication if necessary.

(ii) Immediate notification of the discovery of pests and of natural enemies.

(iii) Exchange of any required specimens and publications.

(iv) The preparation of a list of the host plants and natural enemies of West African insects, with special sections concerning termites and ants.

(v) A study of the food of West African birds (insectivorous and others).

(*b*) We would like to emphasise the value of co-operation between research officers in the same Department.

(*c*) We suggest that at the next Conference an Entomological division should be formed, that papers should be circulated before its commencement, but that discussion should take place at the Conference. It being taken for granted that any officers, other than Entomologists, who wish would attend.

RESOLUTION NO. 4.

The Conference recommends that the West African Colonies exchanging their publications should forward to each other several copies of each publication. It is suggested that for the present twelve copies be sent to Nigeria, the Gold Coast and Sierra Leone, and six to the Gambia.

RESOLUTION NO. 5.

The Conference has duly considered the question of the appointment of an Oil Palm Expert at the joint expense of the Nigerian, Gold Coast and Sierra Leone Governments, and is of opinion, in view of this Conference which will now take place at regular intervals, and the frequent interchange of information on Oil Palm research which has been arranged between the corresponding officers of the respective Governments, that there is now no need for such an appointment.

RESOLUTION NO. 6.

That in the opinion of this Conference it is most desirable that, within the next twelve months, a mission composed of two officers from the West African Departments of Agriculture should visit the Belgian Congo to study the methods there adopted for the development of the oil-palm and the exploitation of its products, and that preferably one of the officers chosen should be one of those who recently went on a similar mission to Sumatra.

RESOLUTION NO. 7.

That this Conference has carefully considered the question of the development of trade between the British West African Colonies and Canada, raised in Despatch No. 3, of the 22nd February, 1927, from the Governor of Sierra Leone to the Governor of Nigeria, and accompanying Sessional Paper No. 1 of 1927, and is of opinion that the British West African Governments should conjointly take active measures to develop the markets of the United Kingdom, Canada, the United States and South Africa, and that a West African Trade or Commercial Intelligence Bureau should be established in each country where the prospects of increasing trade may justify same. It is also of opinion that the Governments should undertake suitable trade propaganda, such as participating in the Canadian National and other appropriate Exhibitions.

The Conference therefore recommends :—

(*a*) That a Joint West African Commercial Intelligence Bureau be established in the United Kingdom at London.

(*b*) That a branch Bureau be established in Canada at Montreal provisionally for the period of five years, on the expiry of which the results would be reviewed to ascertain if they justify the permanent establishment of the Bureau.

(*c*) That the four British West African Colonies participate in the Canadian National Exhibition in 1928, and successive years during the continuance of the West African Bureau at Montreal.

(*d*) That the four West African Governments cause an investigation to be made into the possibilities of the further development of the markets in the United States and South Africa for West African produce, and also as to the desirability of establishing in those countries a West African Commercial Intelligence Bureau.

RESOLUTION NO. 8.

The Governor of the Gold Coast has asked that the Governor of Nigeria place before this West African Agricultural Conference a proposal for the establishment of an Agricultural College for West Africa.

This Conference is of opinion :—

(*a*) that a West African Agricultural College is necessary;

(*b*) that the natural centre for such a college appears to be Nigeria;

(*c*) that in founding the college it is recognised that its work in the beginning should deal primarily with training of the Senior African Staff;

(*d*) that a staff be provided for the college separate from and extra to the staff of existing Departments;

(*e*) that in numbers and training the staff provided be adequate both for the needs of the college and to ensure the prosecution of those branches of research work in agricultural science which cannot be normally carried out by the existing local Departments of Agriculture.

RESOLUTION NO. 9.

This Conference recognises the necessity for the provision of facilities for fundamental scientific research in the West African Colonies, and hopes that adequate provision for such research will be made in connection with the scheme for the proposed West African Agricultural College.

RESOLUTION NO. 10.

(*a*) The Chemical Committee consider that a soil survey of British West Africa is desirable, and should be undertaken by the Agricultural Chemists in and for each Colony.

The survey which the Committee have in mind is of the nature of routine examinations undertaken in collaboration with other members of the agricultural staff.

(*b*) The Committee has considered methods of sampling and analysis, and has prepared a report embodying certain methods which they suggest should be adopted by the various chemical laboratories.

(*c*) The Committee wish to emphasise that a great deal of work is entailed in a soil survey, and that the rate of progress will depend entirely on the staff, accommodation and equipment placed at the disposal of the respective Chemical Departments.

(*d*) The Committee recommend that the following expression of opinion should be forwarded by this Conference to the Agricultural Research Conference to be held in England this Autumn (1927) :—

(i) The Chemical Committee of the West African Research Conference is of the opinion that a Bureau of Soil Science, including a tropical section, would be of great value.

(ii) The Committee suggest that the functions of such a Bureau should include :—

(*a*) The collection and collating of the results of soil investigations in the various colonies, and the publication of a Review comparable with the Reviews of the Bureaux of Entomology or Mycology.

(*b*) Machinery for assisting Agricultural Chemists in the Colonies to carry forward research on fundamental problems beyond the point possible in colonial laboratories where staff and other facilities are limited. It is suggested that the existing research institutions, such as Rothamsted, could be utilised to carry out work of the nature indicated. What is wanted is some method of getting the research worker in the Colony into direct contact with any specialist engaged in investigating the particular problem on which information is needed.

(*c*) The publication of approved methods of classification and analysis of soil, so that the accumulation of the results of soil investigations in the Colonies and Dominions will eventually resolve itself into a soil survey of the Empire, a survey which should prove of great value and importance. (The Chemical Committee forward a copy of methods approved for use in West Africa, for submission to any Committee appointed by the Research Conference to study this question.)

RESOLUTION NO. 11.

In view of the necessity for reliable statistics of agriculture in West Africa, the Conference is of opinion that the Governments concerned should secure from their Directors of Agriculture at an early date an expression of opinion as to the staff and machinery needed to provide for a reasonably accurate system of agricultural statistics.

RESOLUTION NO. 12.

This Conference recognises that the West African Oil Palm Industries are threatened by the establishment in the Far East of well organized plantations and factories for the production of palm fruit and the extraction of its products.

It is felt that this is likely to lead to a reduction in the price of palm oil relative to other vegetable oils, which may cause the value of West African palm oil to fall to a figure such as to discourage the production of low grade palm oil for export.

Should this occur, it is realised that there is possibility of some decrease in the quantity of palm kernels prepared annually for export from West Africa.

In view of this danger efficient steps should be taken to organise the industry so as to prevent the present waste involved by native methods of preparation, and it is recommended that, with due regard to the safeguarding of native interests, the establishment in selected districts of a limited number of factories of approved design and capacity for the extraction of oil palm products should be actively encouraged.

It is further recommended that the study of varieties of the oil palm and their yields, and the breeding of new strains should be prosecuted.

The Conference recognises that though it may be possible to introduce to a limited degree improved methods for the small scale extraction of palm oil by natives, it is not likely that such work will result in a greatly increased production of oil of better quality for many years.

RESOLUTION NO. 13.

This Conference is of opinion that the Governments of the West African Colonies should consider the advisability of providing a system of selection posts in the local Departments of Agriculture on the basis established in India, Malaya and Ceylon;

(*a*) that such post be regarded as an extension of the normal salary scale of technical officers.

(*b*) that these posts should not be necessarily restricted to any one branch of the senior staff of the Departments concerned.

RESOLUTION NO. 14.

This Conference recognises that the training, qualification and experience of Agricultural Officers should not be inferior to those of other scientific research officers in their respective branches, and recommends that the initial salaries of Agricultural Officers should be raised to those now granted to Research Officers.

PAPER No. IV.

OUTLINES OF AGRICULTURAL POLICY IN THE GOLD COAST.

(*A lecture given on January 19th, 1928, to Cadets of the Political Service, by* G. G. AUCHINLECK, *Deputy Director of Agriculture, Chairman of Committee on Agricultural Policy and Organisation.*)

In comparison with most other Government Departments, the local Department of Agriculture is young. Provision was first made in the Estimates for 1889, when £300 were included for founding the Botanic Gardens of Aburi, and the first officer, a Curator, arrived in the Colony on March 16th, 1890.

It is of importance to discuss the reasons which led to the foundation of Botanic Gardens as a means of developing agriculture, since the procedure has had a very distinct effect on subsequent developments of policy. The usual procedure nowadays is to found Agricultural Experiment Stations, but in early days most nations created Botanic Gardens. Thus the Dutch founded Buitenzorg Gardens in Java in 1817, the French Governor of Mauritius started Pamplemousses Gardens previous to 1800, and the British founded Peradeniya Gardens in Ceylon in 1822.

In the beginning, Governments limited their agricultural policy to importing and observing exotic plants, assuming that private enterprise would know how to use them to the best advantage. This earlier work resulted in the exchange between countries of numerous plants of value. In the case of the Gold Coast, we find that cacao was obtained from Venezuela through Fernando Po, and Hevea rubber from Brazil. Nim, Cassia and Casuarina trees which are now used to afforest Accra were obtained from Southern India, Siam and Australia respectively. As recently as last month, a new plant, Hydnocarpus, from which Chaulmoogra oil, used as a cure for leprosy, is obtained, was received locally from Siam.

PAST POLICY TOO LIMITED.

The value of this work is obvious, but it can be carried out more thoroughly and on a more adequate scale on an Experiment Station. In a Botanic Gardens the work is limited necessarily to one or at most two or three specimens of each tree. This fact, coupled with the fact that executive agricultural officers are a very recent development and that earlier work had to be carried out by horticultural men or by specialists in single lines of science, has led to a very real misunderstanding. Only now are Governments realizing that their policy must go far beyond the mere introduction of new plants and the publishing of purely botanical information.

This limited policy was adopted in the Gold Coast much later than in most other tropical countries, and it has persisted longer. Work of the kind formerly carried out in Botanic Gardens is now performed in public gardens or by botanical exploration parties, and, if it enters into Government policy at all, it forms a very minor part of agricultural policy. Nowadays it is as logical to limit agricultural policy to the importation of single specimens of new plants as it would be to stimulate stockbreeding by founding zoological gardens. The kind of work performed by botanic gardens is analogous to that of zoological gardens, and it bears the same relation to agriculture as the latter does to live stock farming.

In order to understand the type of work now required from the Department of Agriculture, one must rid oneself of several misconceptions and misunderstandings which are current locally. In the first place, ornamental gardening and horticulture are not part of the duties of the Department, and they must be provided for separately. In the second place, the importation of economic plants from other countries is only the first step; as the subsequent testing of such plants on an adequate agricultural scale is expensive and laborious, only those plants should be tried which are reasonably certain to be of value.

In the third place, it should be realised that investigation into the commercial possibilities of unknown forest plants is the duty of a botanical explorer, a type of officer whose work belongs to the sphere of "long range research," and who is not likely to be required by the Department of Agriculture for many years to come. Finally, the naturalisation of European vegetables and fruits is not an urgent problem of local agriculture, however interesting and gratifying it may be to European residents, and this kind of work must be done by private enterprise. Any efficiently conducted general store in other tropical countries stocks a supply of vegetable and flower seeds for the needs of local residents, and one may hope to see the same thing done here in due course.

THE PROBLEM OF THE TROPICS.

The tropical belt of the world is peopled by races who have been severely handicapped in the past by unfavourable climatic conditions, and who will continue to be handicapped in the future. They do not produce their full quota of the world's necessities and luxuries, and many of these luxuries and necessities belong to and can be grown only in the Tropics. Cacao, rubber, rice, cotton, cane-sugar, vegetable oils and fats such as coconut and palm oils, coffee, tea, balata, gutta percha, quinine, tobacco, manila hemp and sisal are a few important examples. Some of these were unused weeds a century or so ago, but are now recognised agricultural crops, unfamiliar to the new-comer to the Tropics, but understood by tropical Departments of Agriculture.

The general agricultural and climatic requirements of the commoner tropical crops are well understood. In almost every case the general principles of their cultivation have been worked out by Departments of Agriculture, or by European settlers or European

planting companies in the Tropics. The problem which faces tropical Departments of Agriculture is not the exploitation of totally new products, but the development of existing ones, and the increasing of the per capita output of tropical races. The low standard of output of tropical races as compared with that of temperate climate races can be seen at a glance by comparison of figures of exports. In the Gold Coast, for example, it is about £8 per head, in Malaya, where European plantations are the main agricultural features of the country, it is over £50.

The problems which the local Department of Agriculture has to solve, therefore, is to find out what factors cause the low per capita output of the people and then to devise means for removing them. Only in rare instances do these factors appear to be agricultural: some are educational, some economic, and some political, and no amount of purely technical agricultural skill in field or laboratory can remove them unaided.

This point is of great enough importance to warrant illustration by some recent local examples. The experiment of growing sisal on the Accra plains, and of preparing the commercial fibre, was rightly required of the Department of Agriculture, and the experiment was efficiently carried out: economic factors, labour conditions and peculiarities of land tenure, on which evidence does not appear to have been fully obtained from administrative officers, will probably prevent sisal from becoming a local industry.

There are no agricultural difficulties in the way of efficient cultivation of oil-palms locally, but there are several economic, educational and political factors acting as handicaps or obstacles, which can be cleared away only by administrative action. Coconuts grow rapidly on the sandy coastal strip and in some places inland, and are being planted on communal land by the Department of Agriculture: the problem of extending the industry is an economic and administrative, not an agricultural, one.

Two other examples of a different kind can be mentioned. The work of the Plant Pests Inspectorate from its very inception has been technically efficient and energetically carried out: it was brought virtually to a standstill because the ground had not been adequately prepared beforehand from the administrative and political aspects. Still more recently, the Department has carried out, efficiently and accurately, an extensive series of investigations into the incidence of defects in exported cacao: the utilisation of this information in order to improve the quality of local shipments is not purely an agricultural problem: it will require unstinted help from local merchants, chiefs and political officers, and in addition carefully considered administrative and possibly legislative action by Governments.

THE POLITICAL OFFICER AND AGRICULTURE.

The Department of Agriculture is very rarely faced with a purely technical problem excepting in the course of experimental work in the field or laboratory. Any problem of development is a

complex one in which educational, economic and political factors play a greater part than purely agricultural questions. Consequently, the collaboration of more than one Department is nearly always necessary. Strictly speaking, the agricultural officer is responsible only for purely technical agricultural matters, just as the Public Works Engineer is responsible for making a road and not for evolving and giving effect to a general policy of development of transport. Naturally, in both cases some advisory functions must creep in, but actual responsibility ends with the technical work.

This point must be emphasised, because in the past the agricultural officer has very rarely been judged on the merits of his technical work. He has been held responsible for solving problems of policy and not agricultural problems. This has been illustrated in the cases of sisal, coconuts, oil palms, plant pests inspection and cacao grading, and it applies to other cases as well. In a matter of such general interest and vital importance as agricultural development is locally, everyone assumes the right to criticise, and is none too careful in apportioning any blame he may think necessary. The Department of Agriculture has hitherto been a most convenient whipping-horse for deficiencies in any matter related to agriculture.

The fact of the matter is that agricultural policy is a function of Government in general and not of one Department. Team work between Departments, farmers and merchants is the only means of obtaining satisfactory results, and in this team work the responsibility of the Department of Agriculture must be limited to technical agricultural work and technical agricultural advice.

The administration of Government affairs of the country rests on the political district, and one naturally turns to this fact in considering the best means of evolving and carrying out an agricultural policy. The Committee on Agricultural Policy and Organisation, which sat in 1927, and whose Report will be available shortly as a Sessional Paper, discussed this matter fully. They recommended the establishment, under the Chairmanship of the District Commissioner, of a permanent District Agricultural Committee in each district considered suitable for it. The decision as to the feasibility of establishing and using a Committee lies in each case with the Provincial Commissioner concerned and the Director of Agriculture. A Committee is gazetted by His Excellency the Governor before it functions.

For general matters of agricultural policy affecting the country as a whole, a Board of Agriculture is under consideration. The composition and constitution of the Board and of District Committees may be found in the Report of the Committee of Agricultural Policy and Organisation. It will be seen that both are thoroughly representative, and that the system provides a framework rigid enough to ensure continuity while remaining flexible enough to allow of free discussion and full consideration of all problems of agricultural development. The system operates under an Ordinance, outlines of which are given in the aforementioned Committee's Report.

This, or some similar system, has been found necessary in most tropical countries. Boards of Agriculture exist in British Guiana, Ceylon, Jamaica, Mauritius, Seychelles, Trinidad and the Windward Islands. The Federated Malay States has an Advisory Committee. In Ceylon a system of District Committees operates under the Board of Agriculture. The division of function which results is of benefit to everyone concerned. The Political Officer is provided with the means of obtaining considered opinion upon all aspects of agricultural policy in his district, the Agricultural Officer is free to perform his correct technical and advisory duties, while unofficial members are kept fully in touch with local agricultural problems and with Government's proposals for solving them.

OUTLINES OF PRESENT POLICY.

The agricultural policy of Government has been summarised in the Annual Address of His Excellency the Governor to Council in February, 1926:—

(1) To protect, improve and develop our staple product, cacao.

(2) To develop new agricultural products of export value and suitable to the soil of the country, and for this to maintain experiment stations, to introduce products of proved local value to the farmers, and to encourage their initiation by private enterprise.

(3) To develop food production.

(4) To advertise our resources and wants by means of shows and exhibitions in those countries where the most valuable results would be obtained, and by placing full information at the disposal of the public in our local Agricultural and Customs Offices and in the Commercial Intelligence Bureau in London.

This summary was expanded by His Excellency in the terms of reference given to the Committee on Agricultural Policy and Organisation, and the Committee's Report gives at length the measures and organisation necessary to give full effect to the policy proposed.

In general, the Committee emphasised the fact that up to the present the investigational work of the Department in the field had suffered severely. Advisory duties, instructional work, and extraneous tasks have been developed at the expense of investigational work, and this, combined with shortage of staff, has brought about a partial bankruptcy of exact and reliable knowledge. Planned investigation is the only means of obtaining reliable knowledge, and this is the first deficiency which should be made good by the Department.

It will perhaps not be out of place here to point out that one of the difficulties met with in the past has been the absence of facilities for training agricultural officers. The question is still a difficult one and has not yet been completely solved. The agricultural officer as a general practitioner or executive officer, in the same sense as the

medical or legal practitioner, is a new arrival in the United Kingdom; in illustration of this it may be mentioned that at the Imperial Agricultural Research Conference held in London last October, not a single officer of this kind was present among the delegates of the United Kingdom or Northern Ireland.

There is no Department of Agriculture in the United Kingdom. Since the Great War, Agricultural Advisers have been appointed in each county, and it is probable that eventually they will have to be linked up into a definite administrative department. But up to the present, the question of an organised and consistent policy for agriculture has not been touched. This has had a direct reflection on the Universities, who until quite lately have turned out specialists in single branches of natural science, and are only now beginning to realise the need for the general agricultural administrative officer. A further effect has been that officers appointed to Departments other than that of Agriculture in the Tropics do not realise the scope of Government's duty with respect to Agriculture, nor understand the functions and work of Departments of Agriculture.

Of course, for some time after the necessary type of officer is obtainable, he will be ignorant of tropical agriculture, and special means will have to be adopted for training him. Eventually, as tropical agricultural science becomes systematised, this handicap will be no more severe than it is in the case of Tropical Medical Officers, but for many years yet some new-comers will be without special tropical knowledge. At present, arrangements exist for training a certain number of them at the Imperial College of Tropical Agriculture, Trinidad, but this has proved to be an expensive, inconvenient and not entirely adequate expedient.

AGRICULTURAL INVESTIGATIONS LOCALLY.

The principal lines of agricultural investigation which are being conducted locally are given below. Necessary explanations concerning the actual or potential importance of each crop or each line of work are given in all cases, and in some cases the probable future developments of the various lines of investigation are indicated.

Examination of Cacao at Ports.

This work began on January 1st, 1927, and since then over 36,000 samples have been analysed, representing more than 106,000 tons of cacao. Five classes of defects were noted, the percentages calculated, and certificates issued to shippers. A confidential report covering the period January to July has been printed, and copies sent to all Political Officers.

In the course of the work several subsidiary problems have arisen, as, for example, the effect, on quality, of wetting by sea-water, the cause of slatey internal colour of the bean, correlation between humidity of the air and hygroscopic moisture of the bean, and the magnitude of the errors normal to the method of sampling

employed. Definite and reliable information is now available on most of these points, and where no confidential figures will be disclosed, papers dealing with the points will appear in the 1927 Yearbook of the Department.

The immediate reason for carrying out this work was the refusal of the American Government to admit defective cacao into their ports. A further reason is that, in normal times, cacao from the Gold Coast is valued at a considerably lower price than the product from efficient plantations. There seems to be little doubt that competition from Nigeria, French West Africa and possibly South America will become increasingly severe, and that defects will be severely penalised. Nigeria and Sierra Leone have already passed Ordinances controlling the quality of exported cacao and other raw products.

The majority of the defects of local cacao have now been proved to be due to inefficient methods of preparation, notably insufficient drying of the bean before bagging. Reaping immature, over-ripe and diseased pods are also important causes of defects. Other causes are insufficient fermentation, and careless admixture of foreign matter. The next and logical step is to make use of this information in order to improve the methods of preparation and the quality of local cacao.

It seems reasonably certain that it is not technical knowledge of the methods of preparation that is lacking in the case of the farmer. What is more necessary is the removal of economic and other factors which cause the farmer to prepare his cacao too hastily and insufficiently. Compulsory legislative measures are not accepted as readily here as in Nigeria and Sierra Leone, and other methods have to be explored. Co-operative fermentaries supervised by the Department of Agriculture, certification of cacao prepared in accordance with accepted standard methods, and the gradual establishment of a scale of differential prices based on quality, are among the lines of work indicated. In certain cases, it may be possible to provide for a system of registered buying centres, and the licensing and registering of buyers, but these and other compulsory measures have to be approached with caution.

Control of Pests and Diseases.

There have been no epidemic outbreaks of diseases or pests of crops in the history of local agriculture. Heavy annual losses occur, however, notably through Phytophthora disease of cacao-pods, and the attacks of the bug known locally as Sankonuabe (Sahlbergella) on the stems of cacao.

A text book of Gold Coast Plant Diseases was published in 1924, and a survey of diseases of local cereals and other grasses is now in press as Bulletin 10. A companion volume on insect pests is needed. The life history of two species of Sahlbergella has been published as Bulletin No. 3, and new parasites of Sahlbergella and Thrips have been discovered and are described in the 1926 Year Book.

The Plant Pests Inspectorate founded in 1925 differs markedly from parallel organisations in other countries. Locally, the work was not advisory; the cost of treatment was at first borne by Government, the work was limited to cacao alone, and surgical measures of treatment were the only ones used. This type of work in other countries is adopted only in cases of sudden epidemic outbreaks on a scale too great to be handled by individual planters.

It is a commonplace of agricultural knowledge that diseases and pests of crops are often the sequels to unfavourable agricultural conditions. Shade, protection from wind, drainage, thorough tillage, conservation of soil moisture, manuring and mulching are neglected by the local farmer, and there is a definite connection between this neglect and the occurrence of diseases and pests. Everything points to the advisability of developing these methods of improving the condition of local cacao, and reserving emergency methods of a more artificial kind for dealing with epidemic outbreaks.

Determinations of Yields of Cacao.

Records of yields are not obtainable from the local farmer, and the information is necessary for several reasons, the chief of which is the urgent task of issuing correct and early forecasts of the cacao crop. The present uncertainty is harmful, leading to frequent fluctuations in price, baseless rumours and panics, and a good deal of misunderstanding.

On each of the major local Experiment Stations a dual series of yields records are kept. The yields of measured areas are carefully recorded, and the yields of individual trees kept. All area yields available to the end of 1925 have been published as Bulletin 4 of the Department, and a series of papers on the individual yields of trees will appear in the 1927 Yearbook. These last form the basis for work directed towards breeding high-yielding strains.

Oil Palms.

It has not been possible in any part of the Tropics to establish a stable industry by capitalising a factory which will subsist solely on raw produce brought from small peasant growers. The oil palm industry is not likely to prove an exception to this general rule. The local farmer has neither reputation nor capital to lose, and a contract between him and a factory is not feasible.

A proposal to establish a block of 1,000 acres of oil palms, to be planted and conducted by the Department of Agriculture, and to form the nucleus of a stable system, is under consideration by Government. Part of the Plantation would be of the improved Deli type used in Sumatra and Malaya. With this as a nucleus it would be possible to support an efficient factory which could supplement its supply by purchasing any extra fruit offered by surrounding farmers.

Careful trials of the effect of cleaning and thinning existing wild groves are being made on a comparatively large scale by the Department at Odumase (Eastern Province), Owan (Central Province), and Anaji (Western Province). Results to date prove that this type of work is expensive and the yields obtained are lower than those obtainable from systematic plantations. Four papers on the oil palm industry were published in the 1926 Yearbook.

Coconuts.

This industry is one of potential value for the coastal areas. Comparative yields of 10 plots of Ceylon palms and 10 plots of local palms, an area totalling about 15 acres, are being published in the 1927 Yearbook.

The Department has established areas totalling 745 acres on the coast, and is now erecting model driers for preparing sound copra. The soundness of this procedure has yet to be proved. The plantations are on leased communal land, and they will revert to the people after Government capital has been recovered. They are valuable centres for experiment, from which reliable information will be obtained, and in addition serve as object lessons to the neighbouring villagers.

Sisal.

The economic position and labour supply of the Accra plains and the dislike the local farmer has to handling this crop, will probably preclude any possibility of sisal becoming a local industry. The plantation and factory work now being carried out by the Department are of a high order of efficiency, reliability and interest, and the trial is on a large scale and thoroughly exhaustive. Several reports have been published on this experiment, and the whole story is now being prepared for press as Bulletin 14.

Limes.

Six hundred acres have been established in the Central Province by farmers, and Messrs. Rose, the lime-juice makers, intend installing a trial factory when the area is in bearing. The market is a limited one, and this industry cannot become a large one in any way comparable with such staples as cacao, coconuts or oil palms. Yields are recorded at Asuansi Experiment Station and were published in the Department's Yearbook, 1926.

Cotton.

The success of cotton in Nigeria and in certain parts of French West Africa has naturally excited interest locally. The information at present available indicates two possible centres in the Gold Coast for careful trial of this industry—Togoland and the Northern Territories. In both these areas the crop has apparently been grown for centuries by the inhabitants, the cultivation being mixed with food crops in Togoland, but single in the Northern Territories.

Past trials by the British Cotton Growing Association, and more recently by the Department of Agriculture, indicate that the local yields have been low. The conditions of climate and soil, however, appear closely parallel to those of the northern Nigerian cotton belt, and further trials are being made with improved types of cotton. The Department in 1927 erected a ginnery at Tamale and will buy all cotton produced by the inhabitants. Transport charges are a factor that has to be considered very carefully.

Cola.

This is a crop of very considerable importance, and one on which no information is available elsewhere. Yield-records are kept at Experiment Stations and some have been published in the 1926 Yearbook. The phenomenon of the occurrence of white and pink seeds on the same tree has been cleared up in 1927. It has been found that a graph of the proportion of white to pink on any one tree is in the form of a symmetrical frequency-curve, the proportion rising from zero to a maximum of about 90 per cent. and then falling to zero in later years. The point is an important one, as white seeds are sold at three to four times the price of pink ones locally.

Other Crops.

The Department of Agriculture is and always has been of opinion that an export industry in grape fruit, oranges, pine apples and bananas, and the production of industrial alcohol are unsuited to the local people and to local conditions. Cane-sugar manufacture is an activity suited only to a capitalist land-owning company, and the same remark applies to Hevea rubber and tobacco. Kapok has possibilities, and the superior type grown in Java is being tried now on the Accra plains by the Department. It seems probable that Shea butter nuts may be made a profitable export product, and records of yields are being taken on an established area in the Northern Territories. A small but promising rice industry exists in the Western Province, and the Department has built and is running a milling-factory for the produce.

Coffee.

This is an industry of potential importance locally, and it seems probable that it might replace cacao in the event of the latter crop ever becoming unprofitable. It is planted readily by farmers, local consumption by Africans is increasing, and consequently the berries sell readily. The product is one of the world's great staples its climatic and soil requirements are similar to those of cacao, and the berry requires even less preparation for the market than does the cacao-bean. The Department of Agriculture gives a bonus of £5 to any farmer who establishes an acre of coffee.

The varieties which have been tested at local Experiment Stations, include Arabica, robusta, *Liberica and stenophylla*. Last year the excelsa type was imported from Java. Records of yields are being compiled and will be published shortly. In general,

Arabica coffee is too delicate a type for local cultivation, and the Liberica bean is too coarse and too low priced. Robusta is the popular, hardy type locally, and the bean is of good quality.

Food Crops.

Very little information is available concerning the comparative yields of different types of local food crops. Yields of maize and cassava were determined on major Experiment Stations in accordance with trials ordered by the Government in connection with consideration of the possibility of making industrial alcohol from starch. These yields will be summarised and published shortly. The collection and comparison of local varieties of beans, peas, yams, potatoes, ground-nuts, guinea-corn, maize, jinjili and other Northern Territory food crops, rice, and cassava, should be undertaken early.

There is very little economic pressure at the present moment on the local peasant, and in general he prefers to grow valuable export crops and to use part of the proceeds for importing food-stuffs. The local prices of indigenous foodstuffs are exorbitant in consequence. Whether the present state of affairs be sound and durable or not, the Department of Agriculture should ascertain the costs of production and yields of local foodstuffs.

OTHER INVESTIGATIONS NEEDED.

Knowledge is lacking on several questions of importance, and these are dealt with in the following paragraphs.

Manures and Manuring.

No manures had ever been imported into the Gold Coast by the Department of Agriculture or by private individuals until 1926, nor had any trials been made locally of systems of manuring. Whatever may be the views held of the length of productive life of the cacao-tree and other perennial crops, there is no doubt as to the fact that yields of any crop can be increased, and profitably increased, by correct use of manures.

An eight-plot series has been now laid down at four major Experiment Stations for comparing the effects of various systems of manuring on cacao. The initial variations between the plots in any one series are very great, greater than can reasonably be expected to result from any ordinary system of manuring. These initial errors are dealt with in a paper appearing in the 1927 Yearbook.

There is some evidence that importation and sale of manures will probably be begun on a considerable scale in the near future. As neither the functions nor the correct use of even the commoner manures are understood by the local farmer, there is need for some measure of control of these imports by Government. The

Committee on Agricultural Policy and Organisation has recommended that an Ordinance be passed providing for control of quality and for the production of analyses of imported manures, the Ordinance to be operated by the Director of Agriculture.

Investigations on Soils.

No information concerning the composition of local soils is available yet. The First West African Agricultural Conference, in March, 1927, adopted provisional standard methods of examination and analysis, and the way is now clear for a satisfactory start.

Ordinary observation shows that there are several types of soil-formations in the country, that many subsidiary problems of soil-treatment are awaiting solution, and that in general full treatment of his soil is rarely practised by the farmer. Observations of this kind must be supported or controverted by exact analyses and figures, and knowledge concerning the characteristics of the principal soil-types is urgently necessary.

Compilation of Agricultural Statistics.

In a country of illiterate small farmers, it is practically impossible to obtain statistics of areas, yields, effects of treatment, incidence and spread of disease and other vitally important agricultural figures. At the same time, it is just in that type of country that these figures are most needed: the Government here is obliged to function in a more paternal fashion in all agricultural matters and to undertake wider responsibilities than are necessary in more developed countries. It must at all times have access to reliable figures of areas and yields of major industries, it must watch the progress of promising new products, and it must know well beforehand the probable output of each industry.

Indirect methods of computing yields and areas will have to be used at first. Estimates by Department Officers, meteorological indications, opinions of chiefs and farmers, and other general indications must be employed. The merchants, in their own interests, must give, willingly and reliably, information concerning stocks, movements of produce, information concerning prices, and the movements of foreign merchants.

The Department of Agriculture is now preparing a memorandum on the compilation of crop forecasts, as a reasoned basis for sound statistical work. They have, in addition, asked for provision of an officer on the staff for statistical work.

Agricultural Instruction.

The term "agricultural instruction" has usually been restricted to mean itinerant, verbal advising of adult farmers. This use has been convenient, in that it has roughly demarcated this type of work from agricultural education in schools and colleges and from special lines of demonstrational work.

Agricultural instruction of this type has been given more than adequate trial. It has been carried on to the partial exclusion of reliable experimental work, of publication of exact information, and of organisation of co-operative work. This statement does not refer to the Gold Coast only, most tropical countries having adopted the system as promising a more speedy dissemination of agricultural knowledge. It tends more and more nowadays to be replaced by specialised lines of organised educational and demonstrational work.

As the result of the experience gained, it is possible to give a series of aphorisms concerning agricultural instructions:—

(*a*) Instruction can be based only on reliable information obtained by rigid experiment.

(*b*) A sound experiment is in itself a demonstration and an effective object-lesson.

(*c*) Itinerant, verbal instruction when necessary, can usually better be given by African than by European officers.

(*d*) An adult farmer is nearly always tied by economic difficulties which prevent him from putting sound advice into practice.

(*e*) The spoken word cannot reach as large a public as can the printed word.

(*f*) Adult instruction cannot replace sound educational work, nor does it usually have as rapid an effect.

It would be puerile to continue attempts to effect by verbal instruction improvement which can only be effected by organised education, by systematic experiment, by economic reorganisation, and by political adjustments. The chief lines of organised work which have been started or are recommended are given below.

Publications.

The Department of Agriculture has now a sound system of publications. Three series are published—popular posters, popular leaflets and technical Bulletins. In addition, a scientific Year-book now replaces the technical sections which used to appear in the Annual Report. These publications, notably the Year-book and Bulletins, are the recognised media whereby reliable information is made public. All Political Officers are supplied with copies as the publications appear.

Proposals have been put forward for taking over the journal of the Agricultural and Commercial Society and converting it into a sound quarterly periodical on tropical agricultural matters. In addition a popular Twi magazine of tropical agriculture has been suggested by the Committee on Policy and Organisation. Finally, the Department is at the present moment planning a standard text-book on Gold Coast agriculture, a book that has long been needed.

Rural Economics and Co-operation.

This is practically an untouched field of work, and at the same time one which will amply repay investigation and systematization. Land tenure problems, transport problems, systems of local marketing, the centralization and improvement of minor village industries, co-operative purchase of manure and other supplies, co-operative preparation of cacao, and financing of small farms are a few of the lines of work indicated.

Proposals are with the Government for adding to the staff of the Department an officer for co-operative work, and for sending him to Ceylon and Madras to study the extensive nature of work of this kind there, and to learn the methods employed. A draft Ordinance controlling Co-operative Societies is now under consideration by Government, and when it is passed, certain local societies will be regularised and registered. Kumasi Training Centre and the four Junior Trade Schools are obvious centres for initiating a system of sound co-operative thrift societies.

School Gardens and Pupils' Home Gardens.

The Education Department has consented to inspection of school gardens by the Department of Agriculture, and the work is beginning during the present quarter. Over 1,000 of the Primary School Teachers in the Colony have attended the annual agricultural courses which have been conducted during the past twenty-three years by the Department of Agriculture, and have taken the examination which follows the courses. These courses have been proved inadequate as means of training, and proposals are now being considered for lessening the number of candidates and greatly lengthening and intensifying their training in agriculture.

Work in the garden and associated work in the school can be most effectively systematized and standardized if a simple handbook of nature study and elementary agriculture were prepared, and such a handbook is being planned by the Department of Agriculture.

Apart from the benefit derived by the children from nature-study lessons and school garden work taught as ordinary, normal parts of the day's lessons, the system reflects beneficially on existing agriculture. Each garden acts as an object lesson to villagers, the children carry novel views and ideas into their homes, and new types of food crops and other plants placed in school gardens by the Department eventually spread to the compounds of the village. Really good school garden work can be done if an ordinary amount of advice, guidance and sympathy is shown to the Teachers, and their keenness stimulated by judicious recognition.

Agricultural Shows.

Shows are a recognised activity locally, and have been organised under the auspices of the Agricultural and Commercial Society for some years past. Undoubtedly a certain amount of good results from them, but certain remediable defects need to be mentioned.

The aims and objects of an agricultural show should be more clearly defined and understood. In origin, shows are really meetings between keenly competitive growers with a view to comparing their products. In other words, the first requirement is keen work, the second requirement is keen competition. The prize is merely the recognition of having won the contest.

This process has been inverted in primitive tropical countries. Prizes are offered by an external authority in order to induce the farmers to bring their products together, in the hope that this will give rise to competitive feeling and so eventually produce more efficient work.

It is clear that, under these conditions, every effort should be made by those responsible for organising a show to give long notice of the event, to excite a spirit of competition beforehand, and to reward those entrants who show proof of having prepared longest and worked hardest towards winning. This is not always observed in local Shows, which too often consist of a mere collection of produce brought together by command, and which neither arise from nor stimulate any spirit of competition.

It is not customary locally to charge an entrance-fee at Shows. While this arrangement is probably necessary in very primitive districts, it is open to some question in more advanced countries. The very fact that it is free raises a question in the villager's mind whether it can be of very much value, and the result is that few exhibits are brought in and few onlookers attend. In general, local Shows are considerably below those of other tropical countries in number of exhibits, quality of exhibits, number of onlookers, and in competitive spirit.

Crop Competitions and Crop Bonuses.

Crop Bonuses have been given locally for coffee only. The system appears to have given fair results, and it is probably an effective though somewhat expensive means of extending a new industry.

Crop Competitions are held annually in most cacao districts of the Colony. The prizes offered are fairly considerable, the number of entrants usually very large, and the spirit of competition is keener than that exhibited in connection with Agricultural Shows. The fact that competing farms are inspected before the actual judging takes place is a point of importance, as competitors are stimulated into making some effort to win the prize. The system might very well be extended to crops other than cacao.

CONCLUSION.

The immense range of subjects which have to be considered by Government in embarking on a policy of agricultural development in a tropical country is only now beginning to be realised. It is only to a very small extent a technical problem, and questions of education, organisation, finance and administration are the chief points now awaiting investigation and settlement. The Political Officer has to play a large part in these matters, and it is not too early to begin now to consider the factors which hamper development in each district of the country, and to plan for their removal. The work will not only be of unusually great importance, but it has the advantage of being more than ordinarily interesting. A series of papers by Political Officers on political factors affecting District agriculture would be welcomed as contributions to the agricultural periodical which it is proposed to found.

PAPER No. V.

AGRICULTURAL SURVEY IN CONNECTION WITH THE PROPOSED NORTHERN TERRITORIES RAILWAY.

By G. C. Coull.

1. This report has been written principally to describe the types of vegetation met with, and the products which grow or are grown at present, and what products are capable of being produced.

2. It is impossible to estimate perennial crops, and in Ashanti there are two types of such products: the indigenous perennial crops as cola, oil palm and funtumia rubber, and the exotic perennials as cocoa and para rubber.

3. The trade statistics do not give any idea to the potential wealth of the country, and it would need an extremely accurate survey of the country to do this.

4. In the Northern Territories shea-butter is the only perennial crop of importance. An estimate of this has already been made, and this product is very widely scattered throughout the Protectorate. (See Sessional Paper VII., 1925-26.)

5. The estimates of annual crops have been entirely based on population.

6. With the advent of a railway there is a possibility of itinerant labourers settling along the line and growing crops for export. If such a thing happened a very great increase could be looked forward to in annual crop production. It is interesting to note that practically the same number of passengers passed Yeji going south as passed going north, namely, 44,265 and 44,209 respectively. Probably the majority of the men going south were itinerant labourers seeking work, and I should say that coming north there was an equivalent number returning from work.

7. From the census reports it would appear that the population in the Northern Territories is increasing slightly, but at what rate it is impossible to say.

LOCATION.

8. There are two routes proposed which will be described as the Eastern route and the Western route.

9. The Eastern route runs approximately—

Kumasi — Offinsu — Aboifur — Sekodumase — Abease — Akamadei — Tammle — Nasia — Naga — Santejan — Walembele — Daffina.

10. The Western route runs approximately—

Kumasi — Nkwanta — Sunyani — Tainsu — Bamboi — Bole Wa — Daffiana — Walembele — Santejan — Naga.

PHYSICAL FEATURES.

11. From Kumasi north by both routes every type of vegetation is met with, from the deciduous forest to savannah.

12. Generally, the deciduous forest runs from Kumasi to the Ashanti—Northern Territories boundary, then in the Northern Territories tree savannah is met with which gradually merges into savannah.

13. From a short distance North of Sekodumase on the East and Sunyani on the West, a certain amount of fringing forest is met with which stretches to the River Volta. This fringing forest is also met with along river banks and in hollows.

AGRICULTURAL PRODUCTS.

14. The agricultural products, which may be looked forward to for export, are—

Cacao	*Theobroma cacao.*
Kolanut	*Cola Acuminata.*
Rubber (indigenous)	*Funtumia Elastica.*
Rubber (exotic)	*Hevea brasiliensis.*
Palm oil	*Elaeis guineensis.*
Groundnuts	*Arachis Hypogea.*
Cotton	*Gossypium spp.*
Shea kernels	*Butyrospermum parkii.*
Benni seed	*Sesamum indicum.*
Bungu seed	*Ceratothceca sesamoides.*
Neri seed	*Citrullus vulgaris.*
Kapok	*Eriodendron orientale.*
Fibre	*Agave Sisalana.*
Fibre	*Hibiscus spp.*

POPULATION.

15. The populations, district by district, through which the two routes run, and twenty-five miles on either side of them, is as follows—

KUMASI	27,000	KUMASI	20,000
MAMPONG	Nil.	SUNYANI	15,000
EAST GONJA	6,000	WENCHI	18,000
WEST DAGOMBA	71,000	KINTAMPO	7,000
SOUTH MAMPRUSI ..	6,000	BOLE	7,000
NORTH MAMPRUSI	150,000	WA	40,000
LAWRA-TUMU	40,000	LAWRA-TUMU	40,000
WA	40,000	NORTH MAMPRUSI	150,000
TOTAL	340,500	TOTAL	297,500

16. Both routes run through districts where there are large towns, and, in these towns many of the inhabitants are traders, itinerant labourers, and foreigners, and therefore unproductive as regards agricultural products. An estimate of 20,500 as such inhabitants on the Eastern route, and 17,500 on the Western route,

has been made. These allowances are necessary when estimating the amount of any crop capable of being grown by the native population.

ESTIMATE OF PRODUCTS.

17. The estimates of crops have been based entirely on population.

18. In dealing with perennial crops it is extremely difficult to make estimations, as one man can keep on increasing his plantation, and he can obtain itinerant labourers to harvest his crop.

19. The estimate of the output of annual crops is entirely dependent on population, and for this purpose the adult male population has been taken as one-ninth of the whole, and the female population as one-seventh of the whole.

20. For purposes of an export an estimate has been given of what one man or one woman can do in addition to the normal work of providing food for themselves. In a country such as the Northern Territories, when dealing with production, it must never be forgotten that the Protectorate is faced with the problem of an annual drought of five months. During the remaining seven months the food supplies of the year have to be raised, and the law of self-preservation naturally makes this of primary importance.

21. The difficulty caused by the present lack of population would solve itself, as it was found there was a ready market for the produce, and so people would be induced to settle from other districts.

22. There is a certain amount of overlapping of products in the various zones of vegetation; the table below shows these zones and their main agricultural products—

Deciduous Forest	..	Cacao, rubber, cola, and oil palm.
Fringing Forest	..	Groundnuts and cotton slightly.
Tree savannah and savannah.		Groundnuts, cotton, shea-kernels, benni seed, bungu seed, neri seed, kapok and fibres.

23. Generally speaking the perennial crops would be produced in Ashanti, with the exception of shea-kernels and kapok, and the annual crops in the Northern Territories, with the addition of shea-kernels and kapok.

24. Each crop will now be discussed by itself.

Cacao.

25. With a perennial crop like this, any exact estimate is impossible, as the farmer can go on increasing his plantation from year to year, and can obtain itinerant labourers to harvest the crop. This is the state of affairs at present in the deciduous forest.

26. It is estimated that 10,000 tons was produced along the Eastern route and 15,000 tons along the Western route, 7,000 tons of this being produced round Sunyani.

Rubber.

27. At present there is practically no tapping, though both routes pass areas of great potential output. The funtumia elastica is indigenous, and there are many trees at present capable of being tapped. Were a market created and a fair price offered, there might be a large export again. Para rubber, though not indigenous, also grows well.

Cola.

28. This crop is indigenous to Ashanti, and both routes pass through large areas of potential supply. This crop is peculiar in so far as the owners of the trees take practically no interest in them.

The method of collecting the crop is as follows:—

Moshis from the North and Lagosians from Nigeria arrive at the beginning of the season and settle down in villages, and remain there till the season is finished, collecting and picking the product. The traders get permission from the owners of the trees to collect the crop, and pay so much per hundred cola-nuts. The trees receive no attention except a periodic circle-weeding, which is done mainly to assist the collection of the ripe fruits as they fall on the ground.

29. It is extremely difficult to find the potential output of this product, but certain figures are available for the present trade. The following table shows the present trade:—

From Kumasi South	10,000 tons by rail.
To North by Western route ..	1,067 tons by headload.
To North by Eastern route	546 tons by headload.
	154 tons by lorry.

30. With a railway running North on either route the up-trade would probably increase greatly, and I should estimate 14,000 tons would be transported.

Oil Palm.

31. There are many areas in the deciduous forest where the oil palm grows abundantly. At present there is no industry. The oil is used locally for soap-making, and the trees are cut down to supply palm wine.

Groundnuts.

32. In the deciduous forest the crop is not grown; it is more common in the fringing forest; in the Northern Territories it is grown universally.

33. The crop is easily cultivated, gives a quick return, is well known to all farmers in the savannah country, and seems one for which there is a future, in the event of cheaper transport.

34. The production of groundnuts is entirely dependent upon the population, and, for purposes of estimating the probable

export, it is estimated that each adult male is capable of producing a crop from one acre yielding 800 lbs., in addition to his ordinary farming. The yield from the savannah country would be:—

	Males.	Groundnuts. tons.
Eastern route	33,666	12,023
Western route	26,389	9,424

35. This merely represents the yield for within twenty-five miles of the railway, and it is considered that, if a market were created, it would be grown in many places served by motor roads and a great increase could be looked forward to.

Cotton.

36. This crop is not grown South of Nkoranza or Kintampo, and very little in the fringing forest: again the Northern Territories seem to be where the export would come from.

37. It is grown through the Protectorate in small quantities for local consumption, and the planting, cultivating and harvesting of the crop is well known to the inhabitants.

38. At present the establishment of this crop for export is engaging the attention of the Department of Agriculture in the Northern Territories, and a great increase in the amount grown is looked forward to. This seems a crop for which there is a future. A cotton ginnery has been erected at Tamale.

39. If each man grew 200 lbs. of seed cotton per annum, the yield would be:

	Population.	Seed cotton. Tons.	Lint cotton. Tons.
Eastern route ..	33,666	3,000	1,000
Western route ..	36,389	2,327	775

Shea-kernels.

40. The shea tree is widely distributed through the Northern Territories, and the amount capable of collection is again dependent on the population.

41. With the advent of the motor road to Tamale the export of shea-butter South is increasing yearly, and in markets near the motor roads it is becoming more common to see shea-kernels, brought in from villages farther afield, purchased by women who extract the butter and sell to traders going South.

42. Last year one commercial firm started buying shea-kernels for export, and they have again started buying this year.

43. The collection of this crop is entirely in the hands of the women, and if only age-long customs could be broken down and the men induced to collect the kernels and sell them, there would be a great increase in the amount that could be collected.

44. The calculated amount capable of being collected by the women is:—

	Population.	Kernels.
	Women.	Tons.
Eastern route	43,286	10,821
Western route	33,928	8,482

This is based on the fact that one woman could collect 5 cwts. of kernels in one season of three months.

Benni Seed (Gingelly).

45. This crop is known and grown in many parts of the Northern Territories, and could be grown on a large scale were the demand created. The oil expressed from the seed is a valuable one which has the property of keeping for a very long period without going rancid. The probable amount might be:—

Eastern route	100 tons.
Western route	80 tons.

Neri Seed.

46. This seed has been valued in England at £17 to £18 per ton, and is grown throughout the Northern Territories and Northern Ashanti.

47. If every woman grew enough to produce 20 lbs. the yield would be:—

	Population.	Neri Seed.
	Women.	Tons.
Eastern route	43,286	390
Western route	34,928	312

Kapok.

48. This is seen principally in the Northern Territories. In the deciduous forest the trees are of such a size that the collection of the floss is entirely dependent on what falls from the trees. It is impossible to state the probable quantity for export, but it is a product which could easily be grown on a large scale.

Fibres.

49. Sisal grows well but is not grown by the natives. The native fibre is a product of two species of hibiscus. The hibiscus fibre has been valued in Liverpool as worth £18 to £19 per ton, with Calcutta jute at £22. It is impossible to state the probable yield, but it could probably be developed were a market created.

Food Crops.

50. It must not be forgotten that there would be a large amount of food crops for the South. The present export of groundnuts, guineacorn, millet and yam is increasing rapidly and is carried to Kumasi by motor lorries.

Summary.

51. The following table summarises the population on the two routes available for producing the crops:—

Population.	Eastern.	Western.
Total	340,500	297,500
Adult males	37,833	33,055
Adult females	48,642	42,500
Adult males for groundnuts, cotton	33,666	26,389
Adult females for shea-butter	43,286	33,928
Adult females for neri seed	43,286	33,928

52. The above table consists merely in the population within twenty-five miles each side of the proposed railway routes; and the production of crops would probably be carried out by many more were a market created.

53. The following table summarises the products capable of being produced along the proposed routes:—

Product.	Eastern.	Western.
	Tons.	Tons.
Cacao	10,000	15,000
Cola	14,000	14,000
Rubber	?	?
Palm oil	?	?
Groundnuts	12,023	9,424
Cotton (lint)	1,000	775
Shea-kernels	10,821	3,482
Benni seed	1,000	80
Bungu seed	?	?
Neri seed	390	312
Kapok	20	15
Fibres	?	?
Totals	48,354	48,088

CONCLUSION.

54. In the Northern Territories, speaking generally, the lack of interest shown by the population in growing crops for money seems to be because once having the money there is nothing to spend it on. With the advent of a railway the inevitable result would be the establishment of stores, and, with the right kind of goods which appeal to the native, it would act as an incentive to him to grow crops, as, by this means alone, is he able to obtain money beyond what is necessary for him to live.

55. The figures I have given in paragraph 51 and 53 are merely for strips of territory alongside the proposed routes, and when dealing with probable increase in products the question of population is of paramount importance. The Eastern route certainly taps a greater population on either side of it in the Northern Territories. The Western route has a large expanse of uninhabited country from Kintampo nearly to Wa, and the British population to the West is very scant.

56. With the advent of cheap transport there seems no doubt that an export of products from the Northern Territories could be established.

PAPER No. VI

DETERMINATION OF THE ACCURACY OF CERTAIN METHODS OF SAMPLING CACAO-BEANS.

By A. B. Culham and J. L. Scott.

Since the inauguration of Cacao sampling in January, 1927, a systematic analysis has been carried out on practically all shipments leaving this country. By this means it is hoped to obtain an accurate survey of the various defects, and to ascertain which of these predominate. It will be seen whether they are due to the physical conditions of the country, to the cultural methods and the varieties grown, or, to faulty preparation of the bean by the farmer. We already know the causes of the various defects. When we know their proportions it will be possible to take steps to remove the conditions which give them their being.

AMERICAN FOOD AND DRUGS ACT.

An impetus was given to the need for sampling by the American Government's refusal to allow the importation of cacao below a certain standard of purity. Since the passing of a law disallowing entry to cacao containing 10 per cent. mouldy beans or 15 per cent. mouldy and weevilly beans, a certain proportion of our produce exported to New York has been condemned. In view of that very liberal standard, this failure shows the very bad condition of our cacao. In addition to the loss of money involved there has been a consequent loss of prestige to the Gold Coast as a cacao-producing country. The matter becomes one for serious consideration when it is remembered that the supply of cacao is steadily approaching the demand and that legislation of a severer type may yet be introduced.

POSITION OF THE EXPORTER.

The exporter is faced with a possible condemnation of his exports, with the resulting trouble and loss of money. While our main object, in instituting such a scheme, was the desire to obtain scientific details for our own use, we had to remember the primary necessity of the exporter. It will therefore be seen that if our sampling was to be of any value to the exporter it had to conform very much to that at present adopted in New York. For

this reason our present methods, except for the actual analysis of the beans, are similar to those used by the American Department of Agriculture. It is our purpose to give some demonstrations of these methods and of the extent to which they are accurate.

THE SAMPLER.

The cacao for analysis is extracted by means of a sampler. This instrument is made of brass, 15 inches in length and conical in shape. One end is a circle 2 ins. in diameter, while the other is sharp point. The inside is hollow and on one side there are three apertures, each large enough to admit cacao beans, *i.e.*, $2\frac{1}{4}$ ins. long and $\frac{1}{2}$ in. wide. A diagram is given in Plate II.

The sampler is inserted into a place mid-way up the side, at right angles to the bag. It is pushed in until "A" touches the circumference and " B " reaches the centre of the bag. By a backward and forward movement a conical section of beans is removed from the bag, as illustrated below. On removal of the sampler the hole made by its insertion is closed by replacing the displaced strands with the point of that instrument. Labourers become so expert in the process that it is often difficult to detect where the bag has been puncured.

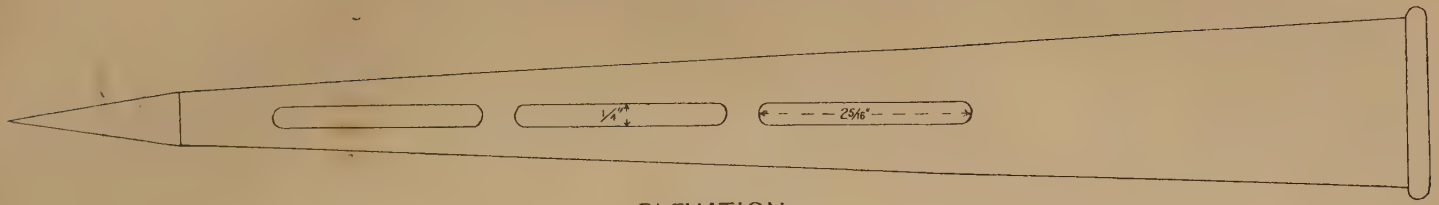
SERIES A.

ACCURACY OF SAMPLER.

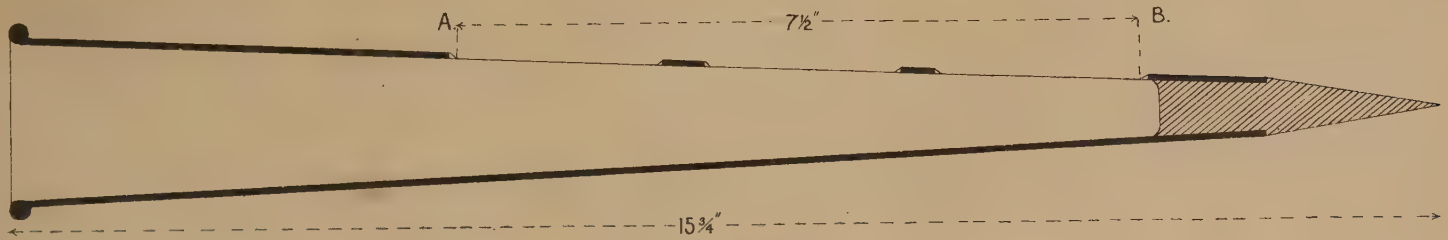
An experiment was carried out with the object of determining the accuracy of the results obtained by the sampler. It also aimed at finding to what extent the reading of one insertion could be expected to give a picture of the cacao in the bag. No instrument can be expected to give accurate results when the contents of a bag are uneven in quality. The experiment was therefore carried out on cacao of even distribution. The conditions were made similar to those obtaining on the beach at Accra.

A quantity of 100 lbs. of cacao was taken, 5 lbs. drawn therefrom, stained blue, mixed with the remaining 95 lbs. and the whole put into a bag of the usual type. The mixing was made as thorough as possible, but, of course, it could not be perfect. The sack was sampled in the manner already described, a count made of 100 beans from the contents, and the percentage of stained beans duly noted. A series of such tests was carried out, care being taken, after each test, to remove the contents from the bag and thoroughly remix, after adding those beans removed in the previous test. $\sqrt{\bar{N}}$ tests were thus made equivalent to the examination of $\sqrt{\bar{N}}$ bags of known standard and reasonably equal distribution of quality. Samples were taken until an average was obtained which gave a negligible error in the percentage of stained beans. Similar experiments were carried out on equal quantities of cacao containing 10, 15, 20, 25 and 30 per cent. stained beans. The figures are given in tabulated form.

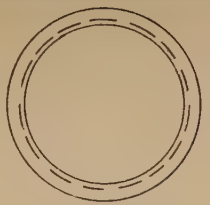
SAMPLER FOR CACAO BEANS



ELEVATION



SECTION



PLAN

Scale: 6 Inches = 1 Foot.

Reproduced at Survey H.Q. Accra, 1928.

Test No.	Exp. No. 1. 5% stained beans.	Exp. No. 2. 10% stained beans.	Exp. No. 3. 15% stained beans.	Exp. No. 4. 20% stained beans.	Exp. No. 5. 25% stained beans.	Exp. No. 6. 30% stained beans.
1	5	15	8	26	28	29
2	6	13	12	16	21	31
3	4	10	13	18	30	30
4	4	9	20	18	35	28
5	4	6	9	26	34	28
6	1	10	14	18	25	29
7	7	14	18	16	24	30
8	5	12	9	28	23	30
9	5	12	11	20	16	49
10	5	10	13	17	27	32
11	6	11	6	26	23	29
12	5	12	15	19	22	24
13	4	6	12	22	23	34
14	5	19	13	23	28	30
15	8	10	21	14	29	27
16	5	10	7	25	33	28
17	5	10	20	23	23	33
18	3	9	16	19	23	33
19	5	11	26	15	24	21
20	8	5	12	20	22	33
Total	100	214	275	409	513	608
Average ..	5%	10·7%	13·75%	20·5%	25·7%	30·4%

The errors of averages were taken after 5, 10, 15 and 20 tests. The results are tabulated below:—

Errors of Averages after tests.	Exp. No. 1.	Exp. No. 2.	Exp. No. 3.	Exp. No. 4.	Exp. No. 5.	Exp. No. 6.
5 tests ..	·7%	·3%	2·8%	·4%	4.6%	·8%
10 ,,	·4%	1·1%	2·5%	·4%	2·2%	1·6%
15 ,, ..	·1%	·2%	2·1%	·4%	·6%	·6%
20 ,, ..	·0%	·7%	1·35%	·05%	·6%	·4%

A perusal of these tables gives the following facts:—

1. Even in cacao of good distribution there are variations between individual samples.
2. No one sample can be depended on to give an accurate description of the contents of a bag.
3. A certain number of samples must be taken before an average of accurate standard can be obtained. Twenty would seem to be that figure. Ten is certainly too small.
4. The variations off-set one another. As only the averages are used in sampling, the sampler seems to be perfectly satisfactory. The accuracy after 20 samples is remarkable.
5. When less than twenty samples are used there is an error. This error is not great, however; moreover, a perusal of

the grading figures will show that less than 2 per cent. of the cacao sampled was in shipments requiring fewer than 20 samples.

Series B.

THE RELATIVE MERITS OF DIFFERENT METHODS OF SAMPLING.

These experiments were carried out in order to determine whether the present method of obtaining samples was better than or inferior to other methods. Using 100 lbs. of cacao containing 15 per cent. stained beans, the following methods of sampling were used: —

1. Sampler at top end of side of bag.
2. Sampler at middle end of side of bag.
3. Sampler at bottom end of side of bag.
4. Sampler thrust perpendicularly into mouth of open bag.
5. Handful of beans from centre of exposed surface in open bag.
6. Handfull of beans from centre of bag with mouth open.
7. Handful of beans from side of exposed surface of open bag.
8. Handful of beans from hole at top end of side of bag.
9. Handful of beans from hole at centre of side of bag.
10. Handful of beans from hole at bottom of side of bag.
11. Handful of beans from bulked cacao on ground.

The results of these experiments are tabulated below: —

Test No.	Exp. No. 1.	Exp. No. 2.	Exp. No. 3.	Exp. No. 4.	Exp. No. 5.	Exp. No. 6.	Exp. No. 7.	Exp. No. 8.	Exp. No. 9.	Exp. No. 10.	Exp. No. 11.
1	9	16	24	8	17	17	21	21	9	19	14
2	8	14	14	17	23	15	13	10	9	17	19
3	15	18	13	18	15	14	16	10	19	15	10
4	17	16	13	9	25	14	17	13	15	21	14
5	17	18	16	13	18	19	20	7	15	10	11
6	8	6	10	9	17	17	17	15	15	22	21
7	15	12	17	12	16	14	13	10	11	21	11
8	14	14	20	7	17	14	16	7	8	21	10
9	15	15	17	17	15	12	19	9	14	17	20
10	16	12	11	12	18	15	22	13	13	18	9
11	20	17	16	7	12	14	18	18	12	18	16
12	8	13	8	12	17	11	14	13	15	14	13
13	15	16	17	18	16	12	19	10	14	12	12
14	19	8	14	13	20	17	12	22	16	8	19
15	19	15	13	12	11	19	16	15	16	20	19
16	15	12	19	18	19	10	20	15	18	18	14
17	13	20	9	11	11	11	11	16	18	12	14
18	16	17	18	17	13	14	17	12	10	20	13
19	24	19	17	9	10	16	15	16	15	20	15
20	14	11	19	12	13	14	14	13	13	11	16
Total	297	289	305	251	323	289	330	265	275	329	290
Average	14·85	14·5	15·25	12·6	16·15	14·45	16·5	13·3	13·75	16·45	14·5

The large variations between different samples is again demonstrated. The importance of having a certain number of tests before taking an average is shown by the following errors of averages:—

Error of Aver. after	Exp. No. 1.	Exp. No. 2.	Exp. No. 3.	Exp. No. 4.	Exp. No. 5.	Exp. No. 6.	Exp. No. 7.	Exp. No. 8.	Exp. No. 9.	Exp. No. 10.	Exp. No. 11.
5 tests	1·8	·6	1·0	2	4·6	·8	2·4	2·8	1·6	1·4	1·4
10 ,,	1·6	1·3	·5	2·8	2·1	·1	2·4	3·5	2·2	3·1	1·1
15 ,,	·7	1·3	·1	2·7	1·5	·1	1·9	2·1	1·6	1·5	·5
20 ,,	·15	·5	·25	2·4	1·15	·55	1·5	1·7	1·2	1·5	·5

A comparison of these errors indicated the following:—

1. All methods gave reasonably accurate results.
2. Four methods gave more accurate results than any of the others.

   They are:—

   (*a*) Insertion of sampler into side of each at top end.
   (*b*) Insertion of sampler into side of each at middle.
   (*c*) Insertion of sampler into side of each at bottom end.
   (*d*) Selections from cacao bulked on floor.
3. In all cases there is a decrease in error of average in proportion to number of samples taken.
4. Insertion of sampler down centre of open bag is the least satisfactory.

It therefore seems that our present methods of obtaining samples are, in addition to being the only apparent and practical ones, the most accurate.

Series C.

METHOD OF EXAMINATION OF A CONSIGNMENT OF CACAO.

Our present methods of examination are based on the mathematical fact that in random sampling, the square root of the number of variations in any collection of figures gives an average which is reasonably approximate to that of the whole. That is to say, in a consignment of cacao containing 400 bags, it will be reasonable to expect a fair picture of the contents from an examination of 20 bags. It must be remembered, of course, that the random selection must be done intelligently and that the 20 bags must be as fairly distributed as possible before a reasonable result can be expected. By this means, not only will an average equal to that of the total be obtained, but the various samples will indicate whether the bags in the consignment are of even quality. It is of the utmost importance to the cacao buyer that not only must his

cacao be of good general quality, but also that it be of even standard. It has therefore been our aim to have sufficient samples to give an exact picture of the quality and at the same time reflect the degree of uniformity. At the same time it has also been necessary to remember that there must be a minimum of cacao removed from shipments, and a minimum of interference with movements of exporters. For these reasons the Department would require very definite knowledge of the inadequacy of the square root method before adopting one in which a greater number of samples would be required.

EXAMINATION OF THE ACCURACY OF THE METHODS.

A series of experiments were undertaken with a view to determining the errors to which this system is liable. The primary aim was to find if the examination of the square root of the number of bags in a consignment gave a reasonable picture of the whole. Such an object can only be achieved in one way, and that is by an actual examination of all the bags in a consignment, taking the average and comparing it with that of the square root taken from the assembled figures.

Such a detailed examination is obviously not practicable. The rapidity of movement of the export trade does not allow time to the limited staff on experimental work, and the amount of cacao removed from a consignment would be considerable. Other methods had therefore to be adopted which were more in keeping with the means at our disposal. One scheme suggested itself which seemed at once practicable and at the same time similar in idea to the one already mentioned.

The figures collected from various ports since January, 1927, contain enough samples to form many consignments. The monthly figures from any port are sufficient to represent a shipment of sufficient size to test the $\sqrt{N}$ method; in addition, having been taken from many different sources, they present a consignment of such extreme variation in quality as to offer a very exacting test of our methods of examination. A detailed description of these experiments and the conclusions drawn therefrom will now be given.

Experiment No. I.

This experiment was carried out to determine whether the square root method would be accurate in a consignment containing large variations of quality. It also aimed at finding whether the method of choosing the bags for inclusion in the square root was likely to affect the accuracy of the result.

The Accra grading reports were therefore examined and those shipments were chosen the samples from which had shown large variations in quality during grading and which at the same time differed markedly in quality from one another. These were totalled together and the average of the whole taken. The results are given below:—

Serial No.	No. of samples of 100 beans.	Total number of beans showing				
		*M.	G.	S.	W.	D.
123	100	289	400	1,384	320	420
155	83	289	362	449	102	239
157	70	323	504	439	225	98
139	67	335	345	373	110	59
192	63	27	91	125	1	79
193	17	16	29	65	7	19
Total ..	400	1,279	1,731	2,835	695	914
Average ..	—	3·2	4·3	7·1	1·7	2·3

Serial No.	No. of samples of 100 beans.	Liverpool requirements.			
		*S.	O.D.	Good.	Total.
123	100	1,384	1,103	7,513	10,000
155	83	449	850	7,001	8,300
157	70	439	984	5,577	7,000
139	67	373	687	5,640	6,700
192	63	125	191	5,984	6,300
193	17	65	68	1,567	1,700
Total ..	400	2,835	3,883	33,282	40,000
Average ..	3·2	7·1	9·7	83·2	—

*M = Mouldy. S = Slaty. D = Defective.
G = Germinated. W = Weevily. O.D = Other Defects.

Different methods of taking the square root were followed.

Method 1. *By choosing the* 20 *samples from six shipments in proportion to the relative number of samples in each shipment.*

Thus we had from

Shipment No. 123, containing 100 bags, — 5 samples.
,, ,, 155 ,, 83 ,, 4 ,,
,, ,, 157 ,, 70 ,, 3 ,,
,, ,, 139 ,, 67 ,, 3 ,,
,, ,, 192 ,, 63 ,, 3 ,,
,, ,, 193 ,, 17 ,, 2 ,,

As far as possible the samples were chosen at equal intervals over each shipment. The individual samples were found to vary much. The percentage good in each will indicate the extent of this variation:—54, 76, 90, 79, 88, 65, 89, 91, 74, 81, 78, 86.

85, 97, 92, 96, 95, 93. The average worked out to be 84·4, thus giving an error of 1·2 per cent. This, to all intents and purposes, is negligible.

Method 2. Random. The 400 samples contained in the consignment were each written down on separate slips of paper. These were mixed up and then placed in groups of five along a table in order to resemble the array of bags on the wharf. Twenty samples were taken therefrom without making any regular distribution, all of them being drawn from the first 20 groups. The following results were obtained:—70, 80, 61, 78, 93, 69, 78, 46, 85, 96, 69, 49, 74, 82, 97, 92, 67, 77, 71, 95. The average worked out at 76·4. An error of 6·8 per cent, was therefore made, showing that in this case the method was not accurate.

Method 3. Experiment No. 2 was repeated, but in this case the samples were drawn from the first 40 groups; an average of 90 per cent. was obtained showing an error of 6·8 per cent. Again, the result was very unsatisfactory.

Method 4. The selection was spread equally over the entire number of groups, i.e., one sample was selected from every four groups. This was repeated eight times, so that 160 determinations in all resulted. The averages are tabulated below:—

Repetition No.	Means of each group of twenty determinations.				
	M.	G.	S.	W.	D.
1	3·2	5·3	6·9	2·1	2·6
2	2·9	3·7	7·3	9·0	1·9
3	3·3	5·2	6·1	2·2	1·2
4	1·2	3·9	4·3	·4	1·3
5	2·4	3·6	5·7	·9	2·6
6	3·4	6·5	8·1	1·8	2·2
7	2·0	5·8	19·9	·1	3·7
8	2·5	3·7	7·4	·9	2·8
Mean of original 400 samples.	3·2	4·3	7·1	1·7	2·3

Repetition No.	Summary of Liverpool Standard.			
	S.	O.D.	Good.	Total.
1	6·2	11·5	81·6	100·0
2	7·3	7·7	85·0	,,
3	6·1	9·6	84·3	,,
4	5·8	6·6	87·6	,,
5	5·7	8·1	86·2	,,
6	7·8	11·3	81·0	,,
7	11·5	10·4	78·1	,,
8	7·4	8·7	83·9	,,
Mean of original 400 samples.	7·1	9·7	83·2	

The percentage good shows errors of 1·6 per cent., 1·8 per cent., 1·1 per cent., 4·4 per cent., 3·0 per cent., 1·8 per cent., 5·1 per cent., 0·7 per cent. This shows that even with careful selection of samples errors varying from 1 per cent. to 5 per cent, are possible. In four tests, the error was less than 2 per cent, and in six cases less than 3 per cent.

As each 20 samples were taken they were not replaced, so that from the figures given above, $^2\sqrt{N}$, $^3\sqrt{N}$, etc., can be calculated. By taking $^2\sqrt{N}$, the error is reduced very much.

As has been already pointed out, the consignment selected was an extreme case of mixed quality. Up to this point the experiments made cannot be regarded as entirely conclusive, and were more in the nature of tentative efforts at finding methods of testing. Certain very definite conclusions can nevertheless be drawn. They are:—

1. The selections must be carefully made. The officer sampling cacao cannot expect accuracy by taking all his samples from one part of a consignment. The sampling must be made as representative of the whole as possible. When the consignment is mixed an error must be expected, no matter how careful the selection may be.

Further experiments were carried out along the lines indicated above.

SUBSEQUENT EXPERIMENTS IN SQUARE ROOT METHODS.

Experiment No. II.

A similar experiment was carried out, using the monthly collection of figures from one port to represent a consignment. At the present time these figures are very even throughout the month. In this case the monthly report from Winneba for the month of October was chosen. Since the individual variations were very small, an accurate result was to be expected from the square root method.

The serial numbers included in the consignment were 51-63, inclusive. The total of the samples in each serial was taken, the analytical figures added together, and the average taken by

dividing the total number of samples. The results are tabulated below: —

Serial No.	No. of samples of 100 beans.	Number of beans showing.				
		M.	G.	S.	W.	D.
51	40	31	104	122	7	63
52	80	97	242	343	26	143
53	35	45	100	132	10	59
54	11	10	30	56	2	16
55	39	73	80	64	75	64
56	29	10	60	166	0	28
57	49	57	198	105	68	89
58	29	19	13	50	0	36
59	28	12	19	74	1	20
60	57	92	80	112	0	129
61	57	80	90	176	2	144
62	49	49	52	118	0	114
63	29	39	20	104	1	46
Total ..	532	614	1,088	1,622	192	852
Average ..	—	1·2	2·0	3·0	·4	1·6

Serial No.	No. of samples of 100 beans.	Summary in accordance with Liverpool requirements.		
		S.	O.D.	Good.
51	40	122	192	3,686
52	80	343	487	7,170
53	35	132	208	3,160
54	11	56	56	988
55	39	64	277	3,559
56	29	166	100	2,634
57	49	105	376	4,419
58	29	50	68	2,782
59	28	74	47	2,679
60	57	112	284	5,304
61	57	176	303	5,221
62	49	118	207	4,575
63	29	104	104	2,692
Total ..	532	1,622	2,709	48,869
Average ..	—	3·0	5·1	91·9

As in the previous experiment, the analysis of each sample was written down on a slip of paper. The 532 pieces were mixed together and then ranged out on a table in groups of five. The square root of the number of samples was taken ten different times,

care being taken to make each distribution as representative as possible, *e.g.*, a slip of paper was taken from the top of group 1, 6, 11, 17, etc. Different groups were used at each test. The results are tabulated below: —

No.	M.	G.	S.	W.	D.
1	1·6	2·2	3·0	·3	2·1
2	1·2	2·1	2·8	·5	1·3
3	1·3	1·9	2·4	·4	1·7
4	1·3	1·6	1·6	—	2·0
5	·8	1·9	2·5	·1	2·3
6	·8	1·8	3·2	·5	2·5
7	1·5	2·1	3·3	·5	1·7
8	1·3	2·0	2·3	·04	1·3
9	1·1	2·0	3·2	·9	1·7
10	1·1	2·0	2·9	·2	1·4
Means of original 532 samples.	1·2	2·0	3·0	·4	1·6

No.	S.	O.D.	Good.
1	2·9	5·9	91·2
2	2·8	4·9	92·2
3	2·4	5·1	92·4
4	3·7	4·7	91·6
5	2·5	4·9	92·6
6	3·2	5·5	91·3
7	3·3	5·5	91·2
8	2·3	4·4	93·3
9	3·2	5·4	91·4
10	2·9	4·5	92·6
Means of original 532 samples.	2·0	5·1	91·9

The results obtained in this experiment are remarkably accurate. The errors of the average of good beans are 0·7 per cent., 0·3 per cent., 0·5 per cent., 0·3 per cent., 0·7 per cent., 0·6 per cent., 1·4 per cent., 0·5 per cent., 0·7 per cent. Only in one test out of the ten was there an error of more than 1 per cent. This proves conclusively that at the present moment the results from all shipping ports are very accurate.

Experiment No. III.

The cacão exported from Sekondi is indicated as being of a very mixed character. The grading report for the month of August, 1927, is easily the worst that has come to this office since

the cacao sampling was started. In addition to the fact that the average for the whole is 58·1 per cent. good, the individual samples vary to an enormous extent. The best sample is 95 per cent. good while the worst is 4 per cent. good. These collected samples present a consignment of as varied a type as it is possible to obtain, and certainly one which appears to be a very severe test of the square root method of examining a consignment. These figures were, therefore, treated in the same way as the Winneba figures were treated in Experiment No. 5. The report includes serials 110-120 inclusive. These were totalled together as in the table below:—

No.	No. of Samples.	M.	G.	S.	W.	D.
110	77	934	485	1,486	186	1,047
111	63	804	386	693	199	613
112	29	283	238	164	95	300
113	19	197	115	169	73	143
114	57	608	372	311	83	351
115	28	316	211	141	89	226
116	45	2,321	994	470	294	561
117	116	2,135	614	600	468	437
118	90	164	127	194	89	229
119	22	222	178	290	74	311
120	25	775	384	286	163	233
Total ..	571	8,759	4,104	4,804	1,813	4,451
Average ..	—	15·3	7·2	8·4	3·2	7·8

No.	No. of Samples.	S.	O.D.	Good.
110	77	1,486	2,652	3,562
111	63	693	2.002	3,605
112	29	164	916	1,820
113	19	169	528	1,203
114	57	311	1,414	3,975
115	28	141	842	1,817
116	45	470	4,170	6,960
117	116	600	3,654	4,746
118	90	194	609	1,397
119	22	290	785	1,425
120	25	286	1,555	2,659
Total	571	3,804	19,127	33,169
Average ..	—	8·4	33·5	58·1

The individual slips were again written on pieces of paper, which were mixed up, grouped into fives on a table and the square root taken from them, in this case 24 samples. Ten different times was the square root of the number of samples selected, care being

taken to have an even distribution of samples. The results are tabulated below:—

No.	M.	G.	S.	W.	D.
1	15·4	8·4	9·0	4·1	6·5
2	14·7	5·8	10·9	4·3	8·5
3	17·0	6·5	6·9	3·1	6·7
4	14·2	7·9	9·5	2·5	7·9
5	14·1	7·3	8·3	4·4	8·2
6	11·5	5·3	9·1	3·3	10·3
7	15·0	5·7	7·1	3·5	7·8
8	18·3	8·2	8·1	2·8	7·7
9	15·9	6·9	8·8	2·5	6·6
10	17·0	6·2	8·6	3·2	7·9

No.	S.	O.D.	Good.
1	9·0	34·2	56·8
2	10·9	33·5	55·6
3	6·9	33·5	59·6
4	9·5	33·4	57·1
5	8·3	33·5	58·2
6	9·1	30·3	60·6
7	7·1	32·1	60·8
8	8·1	35·3	56·4
9	8·75	32·0	59·25
10	8·6	34·4	57·0

The errors are seen to be 1·3 per cent., 2·5 per cent., 1·5 per cent., 1 per cent., 0·1 per cent., 2·5 per cent., 2·7 per cent., 1·7 per cent., 1·15 per cent., 1·1 per cent. These are negligible.

CONCLUSIONS DRAWN FROM EXPERIMENT ON SQUARE ROOT METHODS.

1. Out of 30 tests made on accuracy, 25 gave an error of less than 3 per cent.

2. Those cases in which the error was greater were due to bad selection of the samples.

3. It seems to be certain that if the sampling is made to go over the whole consignment as equally as possible, that the error accruing therefrom is not big enough to cause a significant inaccuracy.

4. In the cases of consignments of unequal quality care must be taken to have samples selected with equal intervals between bags. They must be so distributed as to cover the whole consignment.

5. When the cacao is even the necessity is not so great. An error must always be expected. The results are accurate enough for our purposes.

PAPER No. VII.

PRINCIPLES UNDERLYING THE DETERMINATION OF ERROR IN CACAO-SAMPLING.

By W. H. BECKETT.

In any investigation involving the use of figures to represent characteristics there are different classes of errors. It is usual to refer to the characteristic as an "attribute" of an "individual" in a "population." In this particular case, slatiness is an attribute of the individual, a cacao bean, in the population, which is a consignment consisting of a number of bags of cacao.

The procedure is, briefly, as follows. In a consignment of a number of bags we wish to know the percentage of beans which have certain defects—mould, slatiness, weevil attack, etc. To arrive at these figures, samples are drawn from a proportion of the bags only: the proportion is the square root of the total number of bags. If the consignment is of 1,600 bags, the number of samples is $\sqrt{1,600}$, or 40. These 40 samples are obtained by inserting a cone-shaped sampling tool through the canvas mesh of the bag and allowing the beans to fall through a longitudinal slot into the body of the sampler. These samples are then taken, one at a time, exactly 100 beans counted out, and each bean examined. Counts of each defect are made and entered up. When all the samples have been examined we have a mass of figures, each column representing a particular defect and each row a particular sample. The columns are totalled and the totals divided by the number of rows (samples). The figures thus obtained give the percentages. The problem is to find out how far these percentages represent the actual percentages for the whole number of beans, *i.e.*, the percentages which would be obtained if every bean in the consignment was examined. It is for this reason that an investigation of the errors involved is necessary.

PERSONAL ERROR.

The first class of error may be termed "personal." If two observers made a count of the slaty beans, they might obtain different figures, as the attribute "slatiness" is not a definite "presence and absence" factor. One bean may be on the borderline and be classed as slaty by the first observer but passed by the second. The same error arises in the case of all attributes which are of a qualitative nature. For this reason they are sometimes termed "variables," to differentiate them from the purely quantative attributes, such as "silver" or "alloy" in a count of coins. This type of error cannot be eliminated, but by standardisation it

is reduced to a negligible quantity. If all observers tend to over-estimate, or to under-estimate, a variable, the local result is not rendered unreliable, though in comparing, say, the percentage of mouldy beans given by the inspection on the Coast with that given by an observer in Liverpool it would be necessary to know the relative standards used, and an allowance made if the standards were found to differ. The other personal error is that of pure count. In handling hundreds of samples, an observer is liable to make a wrong count, but the occurrence is rare, and insignificant, especially as the effect of one wrong count is divided by the number of samples in taking out the mean percentage.

MECHANICAL ERROR.

The second type of error is mechanical. In taking samples the method used may introduce "bias." An example of this bias is the selective property of the sampling tool used. If the slot were a quarter of an inch wide only, there would be a definite bias, as only beans under that size would pass through. The slot in the sampling tool used is therefore of a fixed size, and all tools must be exactly the same. In the act of moving the tool while inserted in the bag, the heavier beans might find their way into the slot more easily than the lighter ones. These errors were investigated by weighing, measuring length, breadth and width, and making counts of defects, of beans in a series of samples taken both with the tool and by hand, from the bag and from the bulk. Analysis of the figures shewed that such errors are very small, and may be neglected in practice, though they are of considerable technical interest. Thus, for practical purposes, the sampling tool used has no selective bias.

ERRORS OF METHOD OF SAMPLING.

The third and most important type of error is that due to method, and to appreciate it, we must treat it from a statistical standpoint. As it is impossible to examine every bean, and we resort to partial sampling, the number and size of the samples are important. First, let us take the number. If from ten bags we take one sample, we are taking 1 : 10 chance. If, however, in 100 bags we take 10 samples (the same arithmetical proportion, 10 per cent.), the chance is not 1 : 10. For example, suppose that 10 per cent. of the bags were of poor quality, we should arrive at the correct percentage by taking one sample from a bag of poor quality and nine of good quality. In our first sample we have a 10 : 100 (or 1 : 10) chance of drawing a poor one. After that the chances would be 10 : 99, 10 : 98, etc., until a poor one was drawn, when the numerator of the chance ratio would change. The sum of these chances is clearly not 1 : 10. The chance in any method can be calculated, and provided the method conforms to certain rules of "random" sampling, the chance remains the same, irrespective of the size of the population, if the number of samples is not less than 10, and is a function of $\sqrt{2N}$ where N is the total number of units (bags). By random sampling is meant, samples

taken at random throughout the population. In theory, when a sample is taken (say, of coloured balls from a bag), the ball should be returned before the next is taken. This is practically the case when, in taking cacao samples, they are taken over the whole heap of bags, or as the bags are being handled on the beach. The samples are distributed as evenly as possible over the whole consignment. This is as near as can be got in practice to the theoretical "random" sampling.

For these reasons no method of taking a definite percentage sample, irrespective of the total number of bags, can give as reliable a result. Every tenth bag in 1,000 bags would give a very reliable result, but every tenth bag in 30 bags a result of no value. This $\sqrt{2N}$ method aims at keeping the "precision" (*i.e.*, the reciprocal of the "chance"), a constant, and the square root method in use approximates very closely to the ideal.

STANDARD DEVIATION AND PROBABLE ERROR.

Here again we are dealing with variables and not true attributes, as the percentage of defective beans varies from bag to bag. We are not dealing with a number of units of which some have the attribute "slaty" and others not. Each bag may have from 0 per cent. to 100 per cent. of slaty beans. This gives rise to another set of errors, always associated with the partial sampling of variables. The arithmetic mean of the figures of all the samples gives us an average, but no information of its reliability. If we took the differences of all samples from this mean and summed them without reference to their sign (± or —), a figure termed the average deviation is obtained by dividing the total by the number of differences (samples). This gives us some idea of the variability of the samples. From mathematical considerations a quantity known as the "standard deviation" is much more useful, as from it the reliability of the mean can be calculated. The standard deviation is the square root of the mean of the squares of the differences between the separate counts and the mean. If n is the number of samples, and d_1, d_2, d_3, etc., the differences between the counts 1, 2, 3, etc., and the mean of all counts, then the standard deviation is given by $\sqrt{\frac{d_1^2+d_2^2+d_3^2+d_4^2+\cdots}{n}}$

From this the probable error, E, is obtained by taking 0·67 x standard deviation. This quantity is important. It is an EVEN chance that the true count lies between ± E of the observed count. This is the probable error of only one observation. The "E" of the mean is obtained by dividing this figure by $\sqrt{n}$, where "n" is the number of observations. From this we can calculate the "precision," or reliability, of a result, and see to what extent the heterogeneous nature of the population affects the percentages. In practice it is usually expressed as a percentage of the mean, and is known as the "Coefficient of Error." It is then in a form suitable for comparison. The coefficients of error have been calculated for different method of sampling—$\sqrt{N}$, $\sqrt{2N}$, $2\sqrt{N}$, etc.,

and an analysis of these figures shows that $\sqrt{N}$ gives a suitable number of samples, taking into consideration "precision" and practicability.

The size of the sample, 100 beans out of about 70,000 in a bag, is chosen primarily because it gives direct percentages. The case of error is similar to that above. Here the question is how far the sample represents the cacao in the bag, whereas above it was of how far the number of samples represents the whole consignment. The probable error of one sample is found by taking a number of samples from one bag, and analysing the figures. It is clearly no use aiming at a greater precision in the mean of all the samples from different bags, than in the one sample from a bag. The sample must give us as reliable a picture of the cacao in the bag, as the mean of the samples does of all the cacao in all the bags. The analysis showed that the cacao in a bag is as heterogeneous as are the bags in a consignment, and that the precision of a single sample is low. The sampling tool is designed to take as representative a sample as possible. The elongated cone-shaped allows the sample to come from the centre and the outside of the bag in proportion. A layer of six inches all round the outside of the bag contains much more cacao than the next layer of six inches inside it (depending on the cube of the distance from the centre of the bag). The sampling tool gives a more reliable sample than taking a handful of beans from an opened bag.

BULK SELECTION TO BE TESTED.

Between considerations of number and size, come methods of "bulk selection." A large number of samples are taken, and by bulking in lots, the number is reduced. This is permissible in some cases of sampling, provided the final number of samples is not less than ten. Several of these methods were tried and the probable errors calculated, but insufficient data was collected when the writer was transferred to other duties. It is not certain whether bulk selection is possible with cacao samples, and further work is necessary to elucidate the point.

The errors considered above arise mainly because the material is heterogeneous. In a perfectly homogeneous population, the errors are of a definite order and can be obtained by pure mathematics. If the variable is of the order x per cent. in an homogeneous population, the standard deviation is given by

$$\sqrt{\frac{x\,(100 - x)}{100}}$$

By a comparison of the theoretical coefficients of error with the errors found by actual experiment in a set of samples, the degree of heterogeneity can be found. Both in a single bag and in a consignment of bags it is high, but by the use of the sampler, and by taking the mean of a comparatively large number of samples, the percentages obtained give a reasonably accurate picture of the cacao in the consignment.

PAPER No. VIII.

EFFECT OF SEA WATER ON MOULD IN CACAO BEANS.

By J. L. SCOTT and W. R. HUDSON.

There has been in the past a certain amount of controversy as to the effect of salt water on cacao beans. In the absence of accurate information, ideas on the subject have been necessarily varied. In the course of their duties, the writers have met many who positively assert that, far from being a disease forming agent, it is actually a prophylactic. The question being one of vital interest, it was thought worth while to conduct a series of investigations.

The Experiments and Their Aims.

While the specific purpose of these experiments was an investigation of the above problem, it was thought fit to attempt to solve some subsidiary problems on the same subject, which, while they were not of such paramount importance, were just as interesting. The work was carried out along the following lines:—

(*a*) Effect of salt water on mould formation in cacao beans and on weevil development in cacao beans.

(*b*) Comparative effects of salt and fresh water on mould in cacao beans.

(*c*) Effect of delay in drying wet cacao beans.

In order to obtain reliable information, a series of experiments was carried out. Owing to the fact that the cacao available was limited, work was necessarily slow. The weights of bags employed during the investigation were much less than those of commercial bags, and the results obtained can only be taken as general indications. A detailed description of Experiment I will explain the general procedure adopted throughout.

EXPERIMENT I.

A quantity of cacao weighing 130 lbs. was bulked on the ground, thoroughly mixed, and analysed by taking the average of 20 samples removed therefrom.

ANALYSIS TAKEN BEFORE WETTING.

No.	Mouldy.	Weevilly.
1	3	5
2	2	7
3	3	6
4	2	5
5	7	1
6	3	1
7	5	4
8	2	4
9	5	4
10	2	5
11	3	8
12	4	3
13	4	2
14	3	2
15	4	2
16	2	2
17	5	5
18	6	5
19	2	4
20	4	4
Total	71	76
Average	3·7	3·8

Taking the averages of the first, second, third and fourth series of five samples, it will be seen that they all fall between 3 and 4 per cent. This result may therefore be considered accurate, and in addition, the cacao would seem to have been well mixed. It will be noticed that slight variations occur, but this is naturally inherent in any methods of sampling.

The cacao was divided into three parts of equal weight, each of which was placed in bags, which were treated thus:—

Bag No. 1.—Saturated in sea water and left undried.

Bag No. 2.—Saturated in sea water and dried immediately.

Bag No. 3.—Control bag.

The bags were stored under exactly similar conditions and analysed at weekly intervals throughout one month, this being approximately the time elapsing between shipment and delivery at the port of destination. As each bag weighed only 43 lbs., an accurate reading could be obtained by using the average of five samples. In the other experiments, which were carried out, different treatment was accorded the bags in order to suit the ends in view, but the general procedure was the same. The results obtained will now be considered under the headings already given.

Effect of Salt Water on Mould in Cacao.

The following tables give the result of three series of investigations:—

Date of Analysis.	Bag wet in Sea Water and left undried.		Control Bag.	
	Mouldy.	Weevilly.	Mouldy.	Weevilly.
	EXPERIMENT I.			
7/12/27 before Wet	3·7	3·8	3·7	3·8
14/12/27 after ,, ...	50·8	6·0	2·6	5·8
21/12/27 ,, ,, ...	55·8	6·6	4·8	4·2
28/12/27 ,, ,, ...	60·8	6·2	3·0	5·6
4/ 1/28 ,, ,, ...	61·2	6·2	5·0	4·2
	EXPERIMENT II.			
17/12/27 before Wet	1·9	0·3	1·9	0·3
24/12/27 after ,, ...	41·6	0·0	2·4	0·4
31/12/27 ,, ,, ...	62·8	0·0	2·8	0·6
7/12/27 ,, ,, ...	70·4	0·4	2·6	0·2
14/12/27 ,, ,, ...	72·2	0·0	3·4	0·0
	EXPERIMENT III.			
23/12/27 before Wet	2·4	0·3	2·4	0·3
30/12/27 after ,, ...	49·8	0·0	2·4	0·2
6/ 1/28 ,, ,, ...	75·2	0·4	3·6	0·2
13/ 1/28 ,, ,, ...	79·6	0·0	3·8	0·0
20/ 1/28 ,, ,, ...	76·2	1·2	3·0	0·4

These figures leave no doubt as to the effect of salt water on cacao beans. It would seem that the maximum amount of damage is done during the first week after wetting and that then the rise is afterwards more gradual. The conditions under which the cacao was stored were not as favourable to mould formation as are those on cargo vessels. The bags were small, allowing of more rapid drying, and the open verandah afforded free access to any wind which might have come. One would therefore expect a larger rise in percentage of mould in cacao stored in the hold of a ship. There is no evidence to show that weevil also is in any way affected.

Comparative Effects of Sea Water and Fresh Water on Cacao-Beans.

It is very difficult to make an accurate comparison between the mould forming capacities of these two agents. The actual judgment of mouldy beans is done by the naked eye and is not by any means absolute. No two bags of cacao can be subjected to exactly the same influence, nor can the beans be said to be wet to exactly the same degree. Our purpose, however, is to give a general indication and to find out whether the difference between the two is large enough to be of economic significance.

Knowing the difficulties which have just been mentioned, great care was taken to ensure as similar conditions as possible for the two bags treated. Both weighed exactly the same, and were immersed in their respective fluids for two minutes. They were stored side by side and then subjected, as nearly as possible, to

the same external influences. Only one experiment was carried out, and the results are given below:—

Date of Analysis.	Cacao Wet in Sea Water.		Cacao Wet in Fresh Water.	
	Mouldy.	Weevilly.	Mouldy.	Weevilly.
23/12/27 before Wetting ..	4·7	0·3	4·7	0·3
30/12/27 after ,, ..	49·8	0·2	57·2	0·0
6/ 1/28 ,, ,, ..	75·2	0·4	73·2	0·2
13/ 1/28 ,, ,, ..	79·6	0·0	80·8	0·0
20/ 1/28 ,, ,, ..	76·2	1·2	80·6	0·2

This evidence would seem to indicate that there is no significant difference between salt and fresh water as mould formers in cacao beans. Similar absorption probably gives identical mould formation.

Effect of Drying Cacao Wet by Sea Water.

It has already been mentioned that cacao which has been thoroughly saturated by sea water is sent back to store and dried. Some period usually elapses between wetting and drying, however, and it was thought worth while to investigate the effect of such delays.

The following tables show the results of drying immediately and delaying for 24, 48 and 72 hours respectively. By drying is meant exposure to sun until the crispness of good commercial cacao is obtained.

Drying Immediately.

Date of Analysis.	Dried immediately after Wetting.		Control.	
	Mouldy.	Weevilly.	Mouldy.	Weevilly.
	EXPERIMENT I.			
7/12/27 before Wetting ..	3·7	3·8	3·7	3·8
14/12/27 after ,, ..	3·4	3·6	2·6	5·8
21/12/27 ,, ,, ..	4·2	1·8	4·8	4·2
28/12/27 ,, ,, ..	4·4	4·8	3·0	5·6
5/ 1/28 ,, ,, ..	6·0	3·6	5·0	4·6
	EXPERIMENT II.			
17/12/27 before Wetting ..	1·9	0·3	1·9	0·3
24/12/27 after ,, ..	2·4	0·4	2·4	0·4
31/12/27 ,, ,, ..	3·4	0·2	2·8	0·6
7/ 1/28 ,, ,, ..	3·4	0·2	2·6	0·2
14/ 1/28 ,, ,, ..	4·0	0·4	3·4	0·0

Drying immediately after wetting prevents the formation of mould.

Drying 24 Hours after Wetting.

In Experiment 3, one bag of cacao wet in sea water was allowed to remain for 24 hours before it was thoroughly dried in the sun.

Date of Analysis.	Dried 24 hours after Wetting.		Control.	
	Mouldy.	Weevilly.	Mouldy.	Weevilly.
23/12/27	2·4	0·3	2·4	0·3
30/12/27	4·2	0·4	2·4	0·2
6/ 1/28	3·6	0·2	3·6	0·2
13/ 1/28	7·2	0·2	3·6	0·0
20/ 1/28	7·0	1·0	3·0	0·4

A significant increase will be observed.

Drying 48 Hours after Wetting.

Another bag in Experiment 3 was allowed to remain wet for 48 hours before drying.

Date of Analysis.	Dried 48 hours after Wetting.		Control.	
	Mouldy.	Weevilly.	Mouldy.	Weevilly.
31/12/27	3·6	0·1	3·6	0·1
7/ 1/28	10·6	0·2	3·4	0·0
14/ 1/28	11·4	0·4	4·0	0·2
21/ 1/28	13·0	0·2	4·0	1·0
28/ 1/28	13·0	1·2	4·5	0·8

The increase is quite easily seen to be a large one.

Drying 72 Hours after Wetting.

Date of Analysis.	Dried 72 hours after Wetting.		Control.	
	Mouldy.	Weevilly.	Mouldy.	Weevilly.
31/12/27	3·6	0·1	3·6	0·1
7/ 1/28	19·0	0·2	3·4	0·0
14/ 1/28	19·2	0·4	4·0	0·2
21/ 1/28	18·6	0·2	4·0	1·0
28/ 1/28	18·4	0·4	4·5	0·8

The figures show that the delay between wetting and drying is a very important factor in the formation of mould, the percentage increase being indirectly proportional to the length of time delayed.

It would seem that every day lost in removing moisture from beans has a deteriorating effect on the cacao. Immediate and thorough drying is the only method of combating mould formation.

CONCLUSION.

It is now apparent that absorption of sea water by cacao is just as conducive to mould formation as that of fresh water, though it is possible that there is a difference in the types of mould formed. Further investigation to differentiate these types would be of academic interest, but does not fall within the scope of this paper.

PLATE III

PLAN OF CACAO FIELD, ASUANSI

NORTH

WEST

EAST

SOUTH

207		156	102		50	49	
206	157	155	103	101	51	48	1
205	158	154	104	100	52	47	2
204		153	105	99	53	46	
203	159	152	106	98	54	45	3
	160	151		97	55	44	4
202	161				56	43	
201		150	107	96	57	42	5
200	162	149	108	95	58	41	6
199		148	109		59	40	
198	163	147	110	94	60	39	7
197	164	146	111	93	61	38	8
196		145	112		62	37	
195	165	144	113	92	63	36	9
194	166	143	114	91	64	35	10
193		142	115	90	65	34	
192	167	141	116	89	66	33	11
191	168	140	117	88	67	32	12
190	169	139	118	87	68	31	
189	170	138	119	86	69	30	13
188	171	137	120	85	70	29	14
187	172	136	121	84	71	28	
186	173	135	122	83	72	27	15
185	174	134	123	82	73	26	16
184	175	133	124		74	25	
183	176	132	125	81	75	24	17
182	177	131	126	80	76	23	18
181	178	130	127		77	22	19
180	179	129	128	79	78	21	20

— COLA SHADE TREES

— BLANK PLANTING SPACES

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PAPER No. IX.

VARIATIONS IN THE YIELDS OF CACAO TREES AT ASUANSI EXPERIMENT STATION.

(The field-trials discussed in this paper have been conducted successively by A. B. CULHAM *and* J. STEELE. *The paper has been prepared by* G. G. AUCHINLECK.—*Editor.)*

Details of the Trials.

The field dealt with in this paper was planted in 1910. The variety of cacao used was Forastero Amelonado, the type which is general all over the Gold Coast (see Bulletin 4 of the Department of Agriculture). An unusually wide planting-distance was adopted, the trees being set out in squares 15 feet apart. There were, in all, eight planting-lines of 29 trees each, or 232 squares of 225 square feet each (15 ft. by 15 ft.), so that the total area was 52,000 square feet, or 1·1983 acres. 207 of the planting-squares were occupied by cacao, 20 by cola-trees used as shade, and five were left blank.

Plate III shows the general arrangement of the field. The figures are the serial numbers of the cacao-trees, the large crosses indicate cola shade-trees, and the small crosses mark unoccupied squares.

The shape of the field, with a length about $3\frac{1}{2}$ times as great as the breadth, results in a high proportion of boundary to area. The actual ratio is 1,110 feet to 52,200 square feet, against a boundary-length of 920 feet to a square of the same area. Plants in the outer or boundary squares are clearly under different conditions to those inside, a difference which may or may not be beneficial, and which may cause some irregularity in yields.

In 1919, when the trees were nine years of age, individual yields of each tree were recorded, and this has been continued regularly since. The tabulated records up to the end of 1926 numbered 1,563, and are too lengthy to reproduce in this paper.

The use of these yield-records as a guide to the selection of high-yielding individuals and at the same time as a means of testing the uniformity of the field appears to involve a contradiction. The first application is based on the assumption that the bearing-powers of the individual trees differ inherently from one another, while the second assumes that differences in the yields of the trees are caused by soil irregularities. The truth probably lies somewhere between the two opposite assumptions. There are inherent differences between individual trees, but the effect of these differences is probably neutralised by the fact that planting was done at random, there having been no conscious arrangement of the different types.

The Field Considered as a Whole.

By summing the yields of all trees, we get the annual yields of the field, which are given in Table I below. The figures for number of pods, the unit in which yields are recorded at the Experiment Station, are converted into pounds of cured cacao

by dividing by 12·5. Ratios of eight and ten pods per pound of cured cacao, found by H. A. Dade (see Bulletin 6 of the Department, pp. 18 and 19), in the cases of farms in the Anyinam area, are too high to be applicable to Asuansi figures. Ratios determined at Asuansi over the whole crops of two fields of Forastero Amelonado for the years 1918 to 1925 (totals of 90,191 and 62,447 pods respectively, being concerned), were 12·0 and 12·8 (see Bulletin 4 of the Department, pp. 23 and 28).

The mean yield of cured cacao per acre in Table I below (674 lbs.), indicates that the field under consideration is slightly above the average in productive power. Fields of Forastero Amelonado on seven local Experiment Stations gave yields which, over an aggregate of 93 years, averaged 595 pounds (Bulletin 4 of Department, page 7). Valid comparison is not possible in every case, since the planting-distances vary considerably, thus:—

Present Field planted at	15′	×	15′	(203 plants per acre)
Aburi Field "	15′	×	15′	(203 " " ")
Asuansi Field V. "	10′	×	10′	(435 " " ")
Kibi, Kumasi and Wiawso "	12′	×	12′	(302 " " ")
Peki "	8′	×	15′	(363 " " ")
Kpeve "	12½′	×	12½′	(278 " " ")

The optimum planting-distances for different soils and climates of the Gold Coast have not been determined. From the fact that the cacao-flower is not light-loving, it seems probable that close planting, up to a greater degree than is usual, may be profitable, particularly if no shade-plants are provided for the field.

Annual Fluctuations of Yield.

The yields of the field are given in the following Table I:—

TABLE I.

YIELDS OF THE WHOLE FIELD.

Year.	Total pods reaped.	Yields per acre.	
		Pods.	Pounds of cured Cacao.
1919	9,568	7,985	639
1920	11,585	9,668	773
1921	10,948	9,136	731
1922	9,450	7,886	634
1923	10,916	9,110	729
1924	9,733	8,122	650
1925	7,278	6,073	486
1926	11,338	9,462	757
Means	10,102	8,430	674

The period of observation is hardly long enough to determine whether the yields are governed by any regular fluctuations, unless the alternation of one low yield with two high ones, observable in the Table, be significant. The yields of perennials are supposed to rise and fall in definite rhythm, which is presumably the resultant of phenomena of exhaustion interacting with meteorological cycles.

There are no signs of lessening yield apparent in these figures, though we shall see later that the constant yields really represent a state of equilibrium between a falling yield of one-half and a steadily rising yield of the other half of the field. The trees are sixteen years old and have had no manuring.

Following is a summary of the results in Table I, shewing the range of annual fluctuations in yield which may be used as an indication of the limits of probable future yields:—

Mean yield of the periods concerned.	Average deviation from means.	Range of yield probable.	Actual yield in following year.
(Pods per acre.)			
1st year 7,985	—	—	9,668
„ 2 years 8,826	± 9·53	7,985–9,668	9,136
„ 3 „ 8,930	± 7·05	8,300–9,560	7,886
„ 4 „ 8,669	± 8·46	7,936–9,402	9,110
„ 5 „ 8,757	± 7·50	8,100–9,414	8,122
„ 6 „ 8,651	± 7·57	7,998–9,304	6,073
„ 7 „ 8,283	± 10·57	7,407–9,159	9,462
„ 8 „ 8,430	± 10·84	7,516–9,344	—

The ranges of variation are great, and in spite of this three yields (7,886, 6,073, and 9,462) fall outside of the indicated ranges. Without any special treatment, it is probable that the 1927 yields will be somewhere between 7,516 and 9,344 pods per acre. Any increase of yield, following on beneficial treatment, would have to be above the top figure of this range before it could be considered significant. The figures illustrate the difficulty experienced in obtaining accurate and reliable results from this method of experiment, as very few methods of treatment are beneficial enough to produce an increase of yield of more than 10·84 per cent. in one year. The treatment would have to be continued for several years until a new mean, for the yields after treatment, had been obtained.

Degree of Uniformity of the Field.

To obtain evidence as to the degree of uniformity of the field, we may consider the field as made up of a selected number of areas and compare the yields of the trees on each area. In Table II below, figures are given for the yields of quarters of the field, quartering being effected in three different ways.

The resultant plots are as follows:—

E, EM, WM, and W obtained by quartering the field into four longitudinal strips by three lines running from North to South.

N, NM, SM, and S obtained by quartering the field by three lines running from East to West.

NE, NW, SE, and SW obtained by quartering the field into corner-plots by two median lines, running from North to South and from East to West respectively.

In each case, the yields per plot have been re-calculated to fifty trees so as to allow for losses or surpluses of trees.

TABLE II.

FIELD CONSIDERED AS FOUR PLOTS.

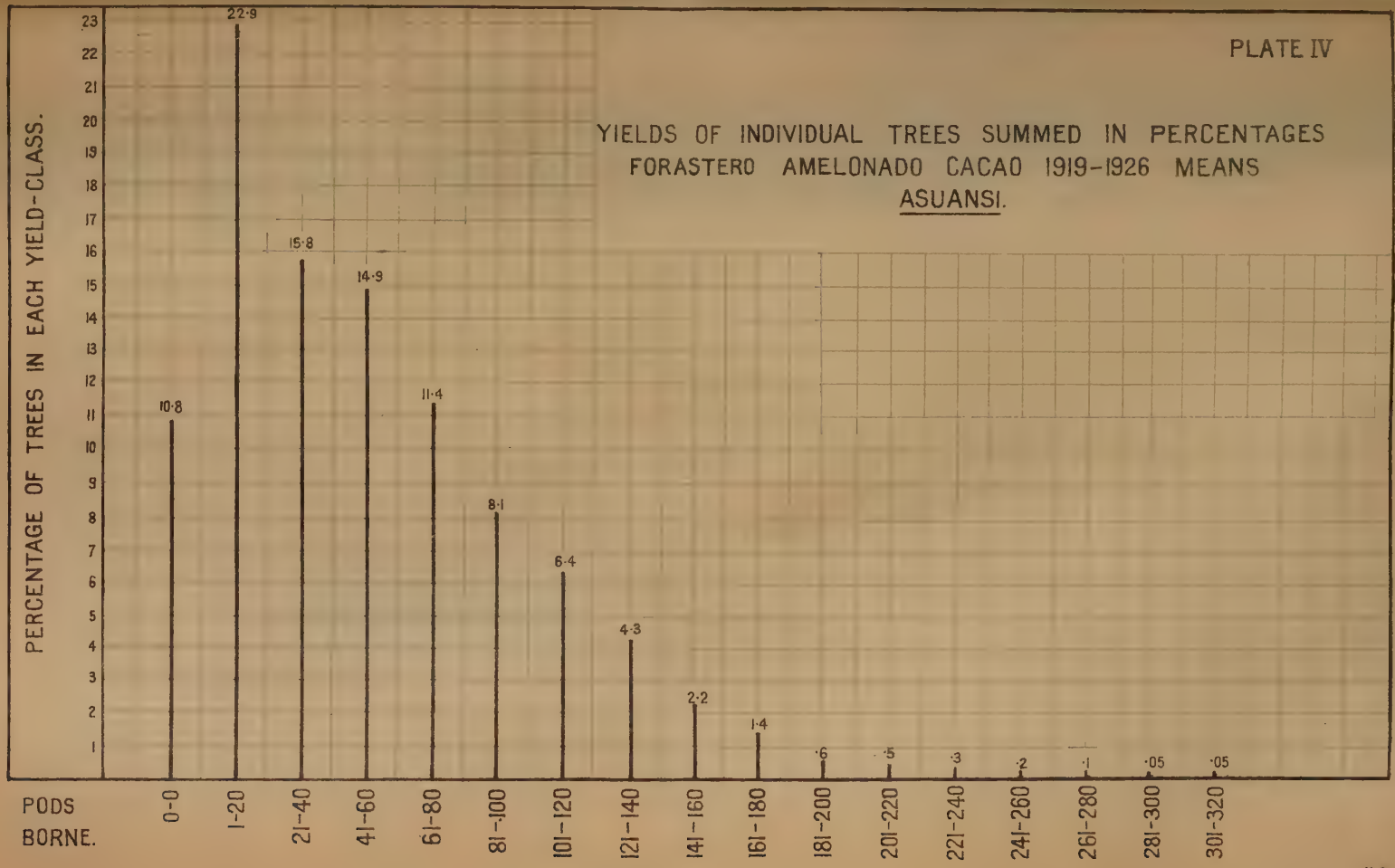
Plot Nos.	Yields in Number of Pods per 50 Trees.								Mean of 8 Years.	Average Deviation % Mean.
	1919	1920	1921	1922	1923	1924	1925	1926		
				A. (Field Quartered by N to S Lines)						
E ...	2,049	3,185	2,957	2,913	3,637	4,351	3,043	4,662	3,350	± 19·4
EM ...	2,398	3,048	2,317	2,737	2,751	2,873	2,242	3,827	2,774	± 12·8
WM ...	2,226	2,552	2,568	1,988	2,233	1,625	1,156	2,013	2,045	± 17·1
W ...	2,569	2,549	2,427	2,173	2,831	1,496	1,278	1,484	2,102	± 24·3
Mean ...	2,310	2,833	2,567	2,453	2,863	2,586	1,930	2,996	—	—
Average Deviation % Mean ...	± 7·5	± 10·0	± 7·6	± 15·2	± 13·4	± 39·7	± 36·9	± 41·6	—	—
				B. (Field Quartered by E to W Lines)						
N ...	2,409	2,993	2,250	2,122	2,326	1,994	1,487	2,450	2,254	± 12·9
NM ...	1,902	2,658	3,276	2,604	3,075	3,457	2,502	3,407	2,860	± 15·5
SM ...	2,631	3,231	3,247	2,551	3,503	2,988	2,083	3 195	2,929	± 12·9
S ...	2,362	2,509	2,369	2,439	2,347	1,684	1,443	2,569	2,215	± 14·7
Mean ...	2,326	2,848	2,785	2,429	2,813	2,531	1,879	2,905	—	—
Average Deviation % Mean ...	± 9·1	± 9·3	± 17·1	± 6·3	± 16·9	± 27·3	± 22·0	± 13·6	—	—
				C. (Field Quartered into Corner-Plots)						
NE ...	2,318	3,411	3,582	3,183	3,376	4,131	2,906	3,433	3,292	± 11·2
NW ...	1,918	2,235	2,096	1,669	2,162	1,534	1,230	1,585	1,804	± 16·6
SE ...	2,170	2,862	2,778	2,578	3,000	3,087	2,374	3,901	2,844	± 12·9
SW ...	2,723	2,806	2,875	2,447	2,847	1,587	1,205	1,911	2,300	± 23·9
Mean ...	2,282	2,828	2,833	2,469	2,846	2,585	1,929	2,707	—	—
Average Deviation % Mean ...	± 10·4	± 10·9	± 13·9	± 16·6	± 12·0	± 39·6	± 36·8	± 35·4	—	—

During 1919 and 1920 the field was fairly uniform, the average deviations in yields of plots being small (± 7·5 and ± 10·0 per cent. for Case A, ± 9·1 and ± 9·3 for Case B, and ± 10·4 and ± 10·9 for Case C). In later years, the deviations increased considerably, reaching maxima of ± 41·6, ± 27·3 and ± 39·6 in the three cases. The reasons for these increases, deducible from the figures and confirmed by knowledge of the field, are the gradual improvement in yield of the Eastern half of the field and the progressive exhaustion of the poorer soil of the Western half. In Case A, the contrast of the E and EM plots with the W and WM areas is very marked, as is aso the gradual decline in yield of the last two. A further indication of this is given by the high annual deviations (± 16·6 and ± 23·9) of plots NW and SW in Case C.

This lack of uniformity precludes the use of the field for ordinary comparative experiments. A line of work which should be carried out is the improvement of the Western half by special treatment. The field should be divided into eight plots by one North-to-South line and three lines East-to-West, and the resulting four Eastern plots retained as controls without special treatment. The four Western plots should be forked, and each treated with a different system of manuring. Mulch, a complete artificial

PLATE IV

YIELDS OF INDIVIDUAL TREES SUMMED IN PERCENTAGES
FORASTERO AMELONADO CACAO 1919–1926 MEANS
ASUANSI.



mixture, pen manure or compost, and slag and potash suggest themselves. The trial would be of special interest in view of the lack of knowledge, locally, of the effects of manures on cacao.

Individual Yields of the Trees.

As the individual records of each tree are too numerous to publish here, they are summarised in the frequency-lists given in Table III, and in the graph opposite (Plate IV).

TABLE III.

(FREQUENCY CURVES OF INDIVIDUAL YIELDS.)

Number of pods borne.	Number of Trees in Each Class.								Mean percentage of Trees in Each Class (8 years).
	1919	1920	1921	1922	1923	1924	1925	1926	
0	23	17	13	11	27	35	26	26	10·8
1–20	37	34	40	54	37	60	55	45	22·9
21–40	34	33	29	38	36	19	29	28	15·9
41–60	45	39	25	25	32	24	25	19	14·8
61–80	37	25	23	19	28	11	17	18	11·4
81–100	15	20	22	19	13	12	10	15	8·1
101–120	10	18	15	16	16	9	7	9	6·4
121–140	4	13	14	3	8	11	3	11	4·3
141–160	1	3	6	4	6	7	4	4	2·2
161–180	1	2	3	2	2	5	4	3	1·4
181–200	—	1	—	2	1	2	1	2	·6
201–220	—	—	—	—	1	2	—	4	·5
221–240	—	—	—	—	1	1	—	2	·3
241–260	—	—	—	—	—	—	—	3	·2
261–280	—	—	—	—	—	—	1	1	·1
281–300	—	—	—	—	—	1	—	—	·05
301–320	—	—	—	—	—	—	—	1	·05
Total Number of Trees	207	205	194	192	192	191	191	191	100·0

A noteworthy feature of this table is the increase of range as the trees grow older. In 1919 the extreme range was 0—180 pods, while in 1926 it had become 0—320. The gradual improvement of the Eastern and the deterioration of the Western half of the field are the chief cause of the increased scattering.

The distribution curve shown in the graph is an unusual one in that the mode (or highest point) is not central between the two extremities of the curve, but occurs near one extremity. Cola trees apparently give a similar type of curve, as exemplified by the curve given in the 1926 Year Book of the Department (Bulletin 7), in the graph facing page 56.

Selection of the Best Yielding Trees.

In order to make use of the mass of records which have been collected, it is necessary to devise some method of analysing the figures so that the consistently productive trees may be isolated.

The Western half of the field is gradually declining in productivity, and in consequence the individual yields are lower here than in the Eastern half. For this reason a mere selection of the

highest yielders in the whole field would not be satisfactory, since many of the plants on the poorer half, though lower in yield, may be inherently superior to those of higher yield on the better half.

In order to overcome this difficulty, the device has been adopted of taking the highest yielders in each half separately for each year, and then testing their continued productivity by noting the number of times that each tree falls into the highest yield-classes. An arbitrary number of the ten highest yielders in the Eastern half and of fifteen in the Western half has been taken for consideration each year. The selections therefore amount to about one-eighth or twelve per cent. of the total number of trees in the field.

The result of this method of selection has been that forty-one trees have emerged which, during the eight years, held all the honours in the Eastern half (80 possible places), while 61 divided the honours for the available 120 places in the Western half. Those trees, which secured a place more than twice, are given in the following Table IV. For purposes of comparison, the mean of all trees in each half of the field is inserted in the Table.

TABLE IV.

(Plants selected for consistently good yields.)

Serial Numbers of Trees.	Times Occurring among Highest Yielders.	Number of Pods Borne by Trees.								Total Number of Pods in 8 Years.
		1919	1920	1921	1922	1923	1924	1925	1926	
Mean Yield of Trees in Eastern Half ..	—	(EASTERN HALF OF FIELD.) 45	63	63	60	68	85	62	96	542
5	Five	72	56	103	161	128	282	152	212	1,166
43	Six	32	137	158	160	133	175	42	223	1,060
41	Three	72	126	105	112	80	220	158	141	1,014
37	Four	65	49	169	117	145	164	126	160	995
58	Three	76	115	100	51	24	154	166	267	953
35	Four	43	174	59	39	71	192	165	193	936
38	Three	39	107	149	28	94	137	136	243	933
40	Three	5	59	128	95	99	211	150	115	862
70	Three	36	60	97	84	136	136	167	135	851
88	Three	78	97	147	44	156	137	25	74	758
54	Three	64	122	106	134	126	75	97	34	758
69	Three	89	107	137	17	35	66	81	220	752
84	Three	79	106	81	62	67	19	73	133	620
Mean Yield of Trees in Western Half ..	—	(WESTERN HALF OF FIELD.) 47	53	52	42	50	29	24	36	333
176	Four	49	139	54	56	146	136	168	254	1,002
143	Four	68	57	57	112	92	165	81	234	866
115	Five	69	58	159	89	201	96	69	110	851
142	Five	71	78	125	103	148	115	108	68	816
132	Four	165	129	96	176	108	75	8	57	814
144	Five	78	78	139	13	108	126	68	133	743
112	Five	36	107	148	109	57	108	32	134	731
197	Three	57	127	86	62	152	130	56	46	716
98	Four	122	147	162	154	98	3	0	0	686
183	Four	131	34	68	83	113	69	79	94	671
133	Three	32	66	64	99	105	78	53	104	601
148	Four	107	5	151	94	62	85	44	1	549
198	Three	122	0	136	138	37	3	3	0	439
194	Three	93	38	13	35	62	95	61	23	420

With very few exceptions, the trees given in Table IV are among the highest as well as the steadiest yielders in the field. Trees No. 98 and 198 may be accepted with little doubt as victims of the poverty of the soil.

There are in the field other trees equal in yield to those in Table IV, but which attained only once a place among the honours or which yielded steadily and well, but missed a place each year. These are given in the supplementary Table below, and they complete the list of all trees in the field which gave yields higher than 750 and 450 pods in the eastern and western halves respectively.

TABLE V.

SUPPLEMENTARY LIST OF HIGH-YIELDING TREES.

Serial Numbers of Trees.	Times among Highest Yielders.	Number of Pods Borne by Trees.								Total for 8 Years.
		1919	1920	1921	1922	1923	1924	1925	1926	
		(EASTERN HALF OF FIELD.)								
34	Twice	14	118	115	190	182	148	79	164	1,010
76	Twice	54	98	116	92	85	223	86	253	1,007
55	Twice	86	177	98	11	38	148	55	311	924
45	Twice	50	49	88	120	114	195	107	122	845
30	Twice	16	70	112	101	120	179	95	201	824
31	Once	0	123	99	82	119	141	101	120	785
63	Twice	8	18	63	88	84	118	196	203	778
39	Once	3	110	54	68	50	149	150	172	756
77	Twice	157	84	68	120	32	94	63	137	755
		(WESTERN HALF OF FIELD.)								
197	Twice	57	127	86	62	152	130	56	46	716
125	Twice	73	103	133	91	96	56	40	95	687
166	Twice	63	28	70	66	225	170	43	0	665
111	Twice	38	56	121	27	143	55	48	100	588
175	Twice	55	105	94	75	129	27	57	40	582
174	Once	65	82	73	85	117	31	57	42	552
200	Twice	90	85	115	34	179	5	11	29	548
178	Once	112	98	53	66	47	40	36	66	518
186	Twice	52	113	90	103	63	25	29	27	502
173	Twice	124	49	93	17	81	12	18	93	487
145	Twice	36	86	140	101	74	23	6	6	472
195	Twice	48	46	35	15	115	51	72	84	466
192	Once	54	99	43	143	82	1	1	42	465
105	Once	42	33	92	69	70	24	7	119	456

The trees, details of which are given in Table IV and its supplement, will serve as starting-points for the work of selecting and propagating high-yielding strains of cacao. Work of this kind is slow and laborious, particularly when it deals with perennial plants, and steps should be taken to ensure that it is not abandoned just when the stage is reached where results may reasonably be expected.

In the present case, the initial step, but only the initial one, is complete. The history and characteristics of each tree are known for a long enough period to render it certain that minor fluctuations and exceptions have been observed and can be discounted. The next step is the propagation of progeny of the selected plants and their careful trial by the Department. It should not be forgotten that the high yields of these plants may not be inherent but may be due to specially favourable positions in the field, and that trial of the second generation is therefore necessary.

It is clearly useless to grow progeny from seed. It is not known whether cacao is normally self-pollinated or cross-pollinated, nor is the ancestry of the selected trees known. Seed is almost certain to produce plants dissimilar to the parents. A vegetative method is necessary, and as cuttings of cacao grow with exceptional difficulty, recourse must be had to grafts or buds.

PAPER No. X.

VARIATIONS IN THE YIELDS OF CACAO TREES AT ABURI EXPERIMENT STATION, 1914–1926.

(*The trials dealt with in this paper were conducted, and the figures compiled by G. H. Eady. The paper was prepared by G. G. Auchinleck.*—EDITOR.)

In the Annual Report of the Department of Agriculture for 1914, the Director mentioned that the individual yields of cacao-trees of Forastero Amelonado type were being recorded at Aburi. The procedure has been sustained up to the present time, and a voluminous series of records, amounting to over 40,000 individual monthly records of yield, is now available.

It seems clear that the observations were intended to provide information on the variations in yield between individuals in the same year, and also the variations in yield which each individual showed from year to year. In addition, the records would enable the Department to propagate high-yielding types for distribution.

Apart from the use of the records as criteria for selection of high-yielding strains, they have proved of definite value as a means of testing the initial variations in quality of different parts of the field. This aspect is dealt with in another paper in this Year-book (" Initial Variation between Plots used for Manurial Trials," by A. B. Culham and others; Paper No. 11).

The Field Considered as a Whole.

In the beginning of the trial, there were 296 trees in the field, planted at a distance of 15 feet square. The trees were planted in 1891-1893 and were therefore 22 to 24 years old when the trials began, and 35 to 37 years old in 1926. During the period of the trial, 58 of the original trees died and were replaced with young plants. These later replantings are not considered in this paper, attention being confined to the remaining 238 of the original trees.

The total yield of the field, and the mean yield per tree for each year, are given in the following table:—

Year.	Total Yield of Field.	Mean Yield per Tree.
	Pods.	Pods.
1914	33,303	115 (289 trees)
1915	20,660	72 (289 „)
1916	31,738	112 (283 „)
1917	24,867	89 (280 „)
1918	35,264	126 (280 „)
1919	31,614	114 (277 „)
1920	20,535	74 (275 „)
1921	26,699	99 (269 „)
1922	21,603	84 (257 „)
1923	17,567	70 (252 „)
1924	21,812	87 (249 „)
1925	20,284	83 (245 „)
1926	26,167	110 (238 „)
Mean	25,547	95 —

Average deviation per year % mean .. ± 18·9%.

A yield of 95 pods is equivalent to eight pounds of cured cacao, so that an acre of 193 trees (15 ft. by 15ft.) would give an indicated yield of 1,544 pounds of cured cacao. The average yield of Forastero Amelonado for many years at seven local experiment stations has been 595 pounds (Bulletin 4 of this Department). The field is therefore an exceptionally good one.

The yield of the field has lessened during the thirteen years of observation. The mean yield per year for the first six years was 29,574 pods and for the second period of six years was 21,417 pods. The year 1926 was an exceptionally good year. The figures are of interest in view of the doubt which has existed locally in the past concerning the length of productive life of the cacao tree. The trees under consideration in this paper were from 35 to 37 years old in 1926.

Individual Yields of Trees.

The records compiled during the thirteen years of observation are far too voluminous to reproduce in this paper, nor is it necessary to publish them. They can be conveniently summarised in the forms of a distribution-curve. In the following distribution-table are given the number of trees which occur in certain arbitrarily chosen

yield-classes, consideration being limited to the 238 trees which survived throughout the thirteen years of observation:—

Mean number of pods per year per tree.	Number of trees in each yield-class.
11–25	4
26–40	12
41–55	16
56–70	31
71–85	32
86–100	28
101–115	40
116–130	36
131–145	24
146–160	10
161–175	4
176–190	1
—	238

The variations in individual annual yields of the trees were greater than in the case of the means given above, the highest figure recorded being 317 pods and the lowest 0.

Selection of Highest Yielding Trees.

In selecting the best-yielding trees two factors have to be taken into account. In the first place the yields must be high and in the second place the high yields must be sustained. The device has therefore been adopted of tabulating the thirty trees which gave the highest yield in each of the thirteen years under consideration, and then ascertaining whether any trees recurred fairly often among these highest yielders.

Results of this method of classification are given in the following table:—

Total places of honour in 13 years	390
No. of trees which secured no places of honour ...	96
No. securing one honour place	46
,, ,, two honour places	30
,, ,, three ,, ,, ...	23
,, ,, four ,, ,, ...	15
,, ,, five ,, ,, ...	18
,, ,, six ,, ,, ...	5
,, ,, seven ,, ,, ...	3
,, ,, eight ,, ,, ...	1
,, ,, nine ,, ,, ...	1
	238

The mean yields of the trees in these classes during the thirteen years were as follows:—

96 trees securing no honour places, 64 pods per year.

99 trees securing three, two or one honour places, 106 pods per year.

43 trees securing four or more honour places, 142 pods per year.

It seems clear that the method of selection adopted is effective.

The yields each year of the forty-three trees securing four or more honour places during the thirteen years are given in the following table:—

YIELDS OF TREES OCCURRING AMONG FIRST THIRTY MORE THAN THREE TIMES.

Tree No.	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	Total and Years.
20	107	163	156	246	223	320	171	251	144	32	168	75	175	2,331 (8)
156	162	55	193	134	247	422	115	169	211	74	155	125	187	2,249 (6)
203	204	124	243	166	232	245	135	252	103	114	102	166	74	2,160 (9)
49	102	110	84	125	193	260	268	206	57	170	215	43	196	2,129 (6)
167	14	7	141	172	254	448	124	283	107	70	129	207	154	2,110 (5)
48	208	125	33	163	179	218	296	150	229	93	137	41	185	2,057 (7)
130	296	17	266	207	173	346	82	169	52	94	49	183	122	2,056 (5)
129	154	93	194	215	203	267	95	128	216	81	148	88	170	2,012 (7)
43	168	220	89	142	161	317	161	186	34	129	181	34	126	1,990 (7)
220	268	100	241	192	266	169	197	115	73	91	58	92	94	1,956 (5)
97	199	296	150	104	207	213	118	108	133	86	144	26	157	1,943 (4)
6	235	145	200	199	145	297	63	140	84	93	73	125	137	1,936 (5)
22	191	218	72	135	129	284	132	202	107	102	145	35	172	1,924 (6)
179	219	63	151	156	251	226	134	151	156	60	193	121	138	1,919 (6)
277	180	86	175	160	329	205	142	71	136	109	88	69	159	1,909 (5)
176	182	23	144	143	163	161	—	—	122	114	239	204	182	1,877 (5)
70	184	247	71	113	164	67	263	129	76	188	176	72	136	1,876 (5)
187	148	83	136	101	137	110	104	170	174	192	153	191	159	1,858 (4)
161	188	48	227	146	213	266	105	164	138	82	110	37	132	1,856 (5)
275	130	143	95	205	261	116	168	77	141	134	138	76	168	1,852 (5)
162	215	63	209	167	251	69	110	154	73	73	97	68	100	1,849 (5)
16	217	145	130	109	136	269	114	188	142	78	97	55	130	1,820 (4)
196	149	93	187	102	161	121	152	131	187	144	111	130	151	1,819 (4)
99	170	18	135	89	140	220	41	93	191	196	180	149	178	1,810 (5)
88	151	8	100	138	261	113	77	193	161	155	134	112	206	1,809 (5)
100	121	9	180	132	201	160	32	118	210	174	134	148	187	1,806 (4)
188	193	91	156	151	198	82	92	202	190	89	—	226	136	1,806 (5)
136	108	68	122	123	197	214	64	197	162	111	97	175	105	1,783 (4)
218	157	52	130	92	134	144	114	176	177	130	117	170	185	1,778 (5)
119	86	30	127	90	262	150	32	100	167	153	234	131	203	1,765 (5)
139	121	96	173	167	151	96	126	61	124	146	133	130	238	1,762 (4)
121	106	21	147	115	126	160	83	78	112	206	157	166	183	1,760 (4)
182	39	32	203	142	218	256	79	207	130	78	140	88	147	1,759 (4)
215	128	89	142	110	201	71	93	199	180	97	177	145	92	1,742 (4)
264	226	102	188	147	212	151	157	64	232	40	43	42	68	1,677 (6)
164	161	26	189	102	133	161	20	171	138	163	130	106	176	1,676 (4)
243	85	67	121	131	241	95	101	115	175	120	58	221	143	1,673 (4)
133	146	52	197	130	155	234	49	135	75	134	149	89	108	1,653 (4)
198	121	129	123	70	173	82	101	205	169	120	50	175	115	1,633 (4)
116	126	85	154	132	170	69	43	196	158	163	123	161	182	1,562 (5)
263	132	132	149	93	176	107	153	12	159	21	162	173	163	1,562 (5)
120	133	42	163	118	177	134	91	60	117	144	150	87	106	1,522 (4)
173	74	43	155	144	211	103	84	190	154	134	121	81	—	1,494 (5)

The next step necessary in these trials should be the securing of budded or grafted progeny from these forty-three selected trees, and their trial in another field in order to ascertain whether the high yields are due to inherent productiveness of the trees or merely to accidents of locality.

PAPER No. XI.

INITIAL VARIATIONS BETWEEN PLOTS USED FOR CACAO MANURIAL TRIALS.

By A. B. CULHAM.

It has become necessary in recent years that information should be sought regarding the effects of various manurial treatments on typical soils on which cacao is grown in the Gold Coast. As the industry ages the need for maintaining, and increasing if possible, the yields of the older farms becomes increasingly obvious. Expansion to new areas has a limit and a more intensive system than that of present practice is indicated.

The only cacao areas over which the Department has complete control are situated on Agricultural Stations, and it is with these fields that experiment has been begun. The stations selected are Aburi, Kumasi, Asuansi and Kpeve, and each is reasonably representative of the surrounding country. In no case is it superior as cacao land. Broadly, the trial on each station consists of two acres of bearing cacao, divided into eight plots of one quarter of an acre each, but for various reasons not connected with the trials it has been necessary to modify the management in some cases. The age of the trees varies on different stations as does the planting distance. These factors are on each station as below:—

Station.	Date of Planting.	Distance Planted.
Aburi	1891—1893	15′ × 15′
Kumasi	1908—1910	15′ × 15′
Asuansi	1912—1915	10′ × 10′
Kpeve	1913—1914	12½′ × 12½′

The trials are limited to the use of mulching and of the less soluble forms of manures, and these were applied first in August, 1926. By mulching is meant the application, from an outside source, of organic matter, such as leaves, mowings, etc., so as completely to cover the surface of the soil. The dates of application of manure per acre are: Basic slag 8 cwts., Sulphate of Potash 2 cwts., and Dried Blood 4 cwts. The treatment of each plot is as follows:—

Plot A. No mulch. No manure.

,, B. ,, ,, Dried blood, sulphate of potash.

,, C. ,, ,, Basic slag, sulphate of potash.

,, D. ,, ,, Basic slag, sulphate of potash, dried blood.

,, E. Mulched. Manure as Plot A.

,, F. ,, ,, ,, B.

,, G ,, ,, ,, C.

,, H. ,, ,, ,, D.

Yields from each plot have been recorded separately since 1st August, 1926. The yields dealt with in this paper are for the period from that date to 31st July, 1927. A table is given showing the area of each plot, number of fruiting trees, actual yield and yield per acre. This table shows an extreme variation of yield on the various plots. The Kpeve field shows least variation, but even here the average deviation of the plots from the mean is ±15·7 per cent. The figures for the other stations are Aburi ± 16·9 per cent., Asuansi ± 21·7 per cent., and Kumasi ± 33·4 per cent. Kpeve also heads the list in point of yield with a mean yield per acre of 14,813 pods. The next in order are: Aburi 13,064, Kumasi 9,442, and Asuansi 6,646.

In seeking a solution of the extreme variations in the yields of the plots on individual stations, the following factors, in addition to those of variation in soil and soil conditions suspected as causing them, are worthy of consideration.

(*a*) Relative positions of the plots.

(*b*) Number of fruiting trees per acre.

(*c*) Age of the field.

(*d*) Effect of treatment.

With regard to (*a*), there appears no indication that the relative positions of the plots is of any moment, as may be seen by reference to Plate V and the table of yields. No two fields have been divided in the same way, and there is nothing to show that any one method is superior to another, or that the relative evenness of the Kpeve plots is in any way due to their positions. They are not appreciably more compact than the others, which show a greater variation, and other things being equal, a greater spread argues a greater variety of conditions. Plot C, situated between B and D, produced pods—921 of the mean per acre, whilst the two latter produced pods + 3,055 and + 1,375 of the mean per acre. Asuansi Plot D, which is between C and E, produced pods— 2,322 of the mean per acre and C and E + 1.866 and — 1,102 respectively. The Kumasi plots show tremendous variation, ranging from + 4,202 to — 5,170 of the mean yield of pods per acre. Position, as such, therefore, cannot be regarded as a factor controlling variability.

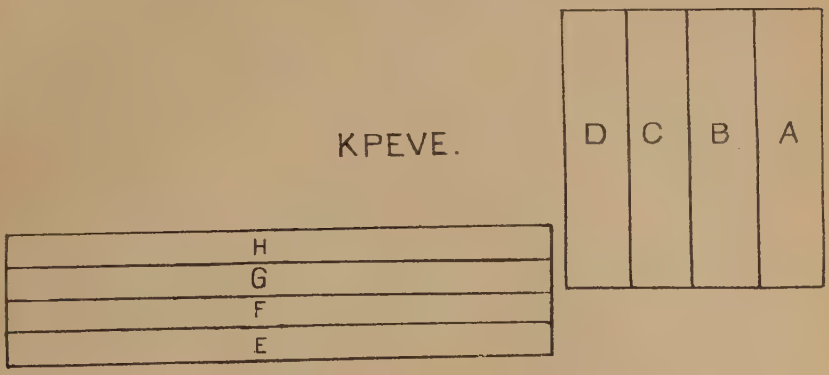
The number of fruiting trees per acre (*b*) is factor which it is safest not to apportion great importance, particularly as the optimum planting distance for cacao on the Gold Coast is not known. Nevertheless it is of interest to note that at Kpeve we have two plots, A and H, each with 48 trees and of the same area and one producing more than twice as many pods as the other. At Asuansi, Plot D, with 82 trees, produced less than half the number of pods reaped from Plot G, which carried only 51 fruiting trees. It is, however, preferred to regard a plot as an area and not as a number of trees.

Whether the age of the field (C) has any stabilising effect is a theory which has some support in the Aburi plots, being much more constant than those of either Kumasi or Asuansi, which are approximately 20 years younger, but Kpeve, the most constant of all, is the youngest.

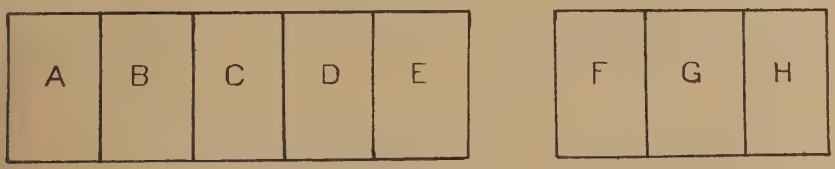
Plots on Agricultural Stations have received considerable cultivation, and the question of the effect of treatment (*d*) is largely bound up with age if it is assumed—it is thought rightly—that under continuous cultivation of the same kind a field would tend towards equalisation of all parts. It is not thought that the application of mulch and manures in the present trials can have had any marked effect on the number of pods produced in the period under consideration, as the main crop is set in August, during which month they were applied. It is also noticeable that the yield of the control Plot A occupied a precedence in pod productions varying from 1 (Kpeve) to 8 (Aburi), therefore whatever effect recent treatment has had, it has not yet had an appreciable one on initial variation. Admittedly it would have been preferable to have measured the initial variation on all plots before the application of the special treatments, but although this was not done, variation in the first year yields can be credited to initial error and not to the treatment during the year.

RELATIVE POSITION OF PLOTS IN CACAO MANURIAL TRIALS.

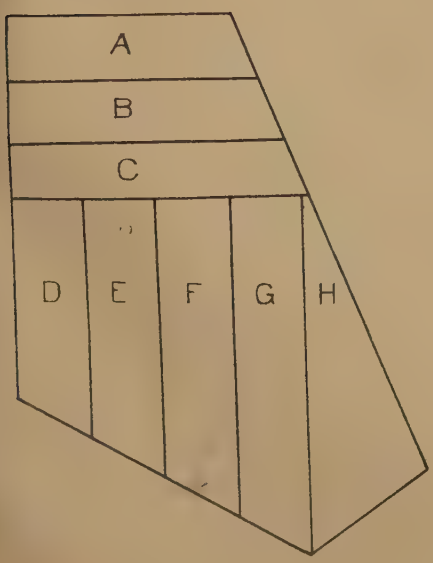
KPEVE.



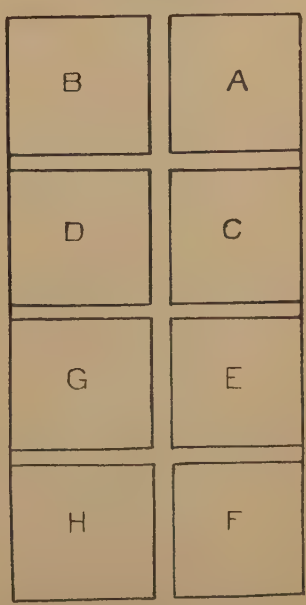
ASUANSI.



ABURI



KUMASI



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STANDARD CACAO MANURIAL TRIALS.

Areas and Yields in Pods Actual and Per Acre, August, 1926, to July, 1927.

Station.		A.	B.	C.	D.	E.	F.	G.	H.
Kpeve	Area and No. of Trees Fruiting	¼ acre 48	¼ acre 62	¼ acre 56	¼ acre 64	¼ acre 55	¼ acre 55	¼ acre 54	¼ acre 48
	Actual Yield	4,921	4,467	3,473	4,047	3,279	3,458	3,439	2,542
	Yield per Acre	19,684	17,868	13,892	16,188	13,116	13,832	13,756	10,168
Asuansi	Area and No. of Trees Fruiting	¼ acre 63	¼ acre 64	¼ acre 76	¼ acre 82	¼ acre 63	¼ acre 55	¼ acre 51	¼ acre 67
	Actual Yield	1,456	2,048	2,128	1,081	1,386	1,634	2,252	1,308
	Yield per Acre	5,824	8,192	8,512	4,324	5,544	6,536	9,008	5,232
Aburi	Area and No. of Trees Fruiting	·27 acre 30	·31 acre 42	·30 acre 41	·20 acre 28	·25 acre 32	·23 acre 35	·24 acre 32	·26 acre 39
	Actual Yield	2,472	3,398	3,078	2,667	3,547	3,475	3,895	3,970
	Yield per Acre	9,163	10,961	10,260	13,335	14,188	15,109	16,229	15,269
Kumasi	Area and No. of Trees Fruiting	⅙ acre 36	⅙ acre 33	⅙ acre 32	⅙ acre 33	⅙ acre 33	⅙ acre 33	⅙ acre 31	⅙ acre 36
	Actual Yield	1,886	1,706	712	1,042	2,055	865	2,274	2,050
	Yield per Acre	11,316	10,236	4,272	6,252	12,330	5,190	13,644	12,300

The overwhelming amount of initial error in this trial due to factors outside the control of the experimenter, indicates that trials such as these are necessarily largely confined to a comparison of the improvement or otherwise in each plot over a period of years and that initial error, although approximately measurable, is sufficient to render these comparisons of little value unless made over a considerable period of years. Striking proof of this is given in the Aburi plots, where individual yields of all trees on the plots have been recorded since the year 1914. Figures closely approximate to the yields are given below. They are not absolutely accurate, as it has been necessary to exclude the yields of 13 trees, now dead, the positions of which cannot, with certainty, be determined. It is not considered, however, that the excluded figures affect the issue.

Approximate annual yields in pods:—

ABURI. (FIELD CONSIDERED AS 8 PLOTS.)

Year.	A.	B.	C.	D.	E.	F.	G.	H.
1914	3,170	2,247	2,957	3,382	3,725	4,235	3,851	3,585
1915	2,070	1,803	1,266	3,490	2,351	1,728	1,948	2,179
1916	3,353	2,592	3,320	2,259	3,783	4,407	4,092	4,222
1917	2,089	1,970	2,249	3,072	3,407	3,190	2,949	3,555
1918	3,789	3,279	3,627	3,598	3,615	4,471	4,309	4,912
1919	2,363	2,184	2,431	4,033	4,377	4,601	3,147	3,360
1920	1,382	1,635	1,653	3,487	2,044	2,142	3,055	2,924
1921	1,855	2,777	3,273	3,288	3,532	4,177	2,998	1,752
1922	1,711	2,381	3,311	1,886	2,819	3,651	3,431	2,717
1923	1,090	2,292	2,600	2,561	2,620	2,511	2,398	2,514
1924	1,330	2,845	3,031	2,886	3,882	3,224	2,921	2,824
1925	1,689	2,508	3,156	1,261	3,527	3,116	3,582	3,400
1926	2,532	3,828	3,231	3,250	3,218	3,413	3,458	4,284
Totals ..	28,423	32,341	36,105	38,453	42,900	44,866	42,139	42,228
Av. dev. from Mean ..	30·1%	17·9%	20·4%	20·5%	16·1%	21·5%	15·6%	21·7%

The following table shows the deviation of the 1926-1927 yield from the mean annual yield.

Plot.	Mean Annual Yield (13 Years).	Yield August, 1926, to July, 1927.	Average Deviation from Mean.
A.	8,041	9,163	13·9%
B.	8,027	10,961	36·6%
C.	9,256	10,260	10·8%
D.	14,790	13,335	9·8%
E.	13,200	14,188	7·5%
F.	15,004	15,109	0·7%
G.	13,505	16,229	20·2%
H.	12,492	15,269	22·2%

It will be seen that in two cases do the 1926-1927 yields deviate to a greater extent from the mean than the average deviation over 13 years. (Plots B and G), one is mulched (G) and one unmulched (B), and the manurial treatment of each is different. The deviations cannot, therefore, be regarded as an effect of treatment.

PAPER No. XII.

CORRELATION BETWEEN RAINFALL AND CACAO YIELDS IN THE GOLD COAST, WITH SPECIAL REFERENCE TO EFFECT OF APRIL RAINS ON THE FOLLOWING CACAO CROP.

By W. T. O. MAIDMENT.

The figures of rainfall and cacao yields are taken from three stations in different localities on the Gold Coast, namely, Aburi, Asuansi and Kumasi, and graphs drawn showing the monthly cacao crops and monthly rainfall from 1920-1925. The variety of cacao in each case is Forastero Amelonado.

There is a distinct parallelism between the monthly rainfall and the monthly crop in each of the three graphs, and if we take the crop graph and move it back until the July crop is over the April rain, and the August crop over the May rain, and so on throughout the year, this fact is brought out more clearly, as the highest points of each curve tend to come together.

Observation of the three appended graphs shows that there is some correlation between the rainfall and the cacao crop. (See Plates VI, VII and VIII.)

PHYSIOLOGY OF FLOWER PRODUCTION.

To assist in making accurate crop forecasts of the probable time and length of harvesting of the cacao crop, the writer puts forward the following theory, which has been suggested from observations of the graph.

In the month of April the majority of the flowers for the main crop are forming and the fruit setting. This is due to a physiological phenomenon on the part of the plant.

To make this point clear, it is necessary to explain what it is that causes a tree to stop producing new shoots and leaves and to begin to produce flowers and fruits. Plant physiologists seem to be of the opinion that it is largely determined by the relative amounts of carbohydrates and nitrogenous substances,* and it is interesting to see whether this view can be applied to the question at present under consideration. The vegetative growth is dependent on the nitrogen supply, which is obtained from the soil, while the carbohydrate supply is dependent on vegetative growth, since it is the function of leaves to produce carbohydrates. At the beginning of a new growing season (which in the case of cacao may be taken to be at the beginning of the first rains, say the end of February), vegetative growth proceeds apace owing to a supply of nitrogen being rendered available to the plant by the rain, due to the renewed activity of the nitrifying bacteria of the soil. At this stage the ratio of carbohydrates to nitrogen in the plant is low, but later, owing to the activity of the newly formed tissues, the ratio of carbohydrates to nitrogen gradually increases, and when a certain

* Some physiological aspects of pruning by E. C. Cheeseman, B.Sc., "The Tropical Agriculturalist," Vol. LXV., No. 5, November, 1925.

point is reached, the behaviour of the growing point is changed over, and flowers are produced. The important point is that the flowers will not be produced until there is enough reserve material in the plant for the production of flowers and fruit.

In an early year the crop definitely commences in August and in a late year does not begin until September.

EFFECT OF APRIL RAINS.

Inspection of the Aburi and Kumasi graphs will show that when the rainfall for April is over six inches, the crop in that year is late and is over by the end of the January. On the other hand, when the April rainfall is less than six inches, the crop in that year is early, and is not over until the end of February. The exceptions to this is in the years 1921 at Kumasi and 1923 at Aburi. The exception in the Kumasi record will be dealt with later.

A comparatively heavy rain in April will induce extra vegetative growth, which may be enough to upset the carbohydrate-nitrogen ratio by a rapid increase in nitrogen content. If this were the case the formation of flowers would be temporarily checked by the extra vegetative growth. When the balance between the carbohydrates and nitrogen is restored, flowering will rapidly proceed, as a result of renewed supply of food material. This may explain the lateness and short duration of the crop.

On the other hand, when the April rains are below this six inches turning-point, there is no extra stimulant given to vegetative growth, and the carbohydrate-nitrogen ratio remains undisturbed. The flowering continues evenly over a longer period and so the crop tends to be earlier and to persist over a longer period.

Inspection of the different graphs show that Aburi and Kumasi, having the same general physical conditions, appear to conform to this theory. This is not so in the case of Asuansi, where there is very little difference in any year between the time the crop commences and the time it finishes. From this it would appear that the theory regarding the amount of April rainfall would only apply to districts of the same physical and climatic conditions as at Kumasi and Aburi, since the general physical conditions obtaining at Asuansi are considerably different from the two former places.

The 1921 crop at Kumasi and the 1923 crop at Aburi would seem to discount the above theory, but in the case of Kumasi this may be explained when the daily rainfall for April is seen. Here most of the rain fell after the 13th of the month, by which time some of the fruit would have set, consequently the crop ranked as an early one.

The above theory is put forward as a possible guide for forecasting the incidence and duration of the cacao crop in those districts similar to Kumasi and Aburi in general physical and climate conditions. If, however, the distribution of rain in any one year is abnormal, as in 1927, when in Kumasi there was a marked shortage of rain from May to September, it would seem probable that the theory would not apply.

Plate No VI

MONTHLY PERCENTAGES OF RAINFALL AND CACAO YIELDS ON KUMASI EXPERIMENT STATION.

45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
Cacao
July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June
Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June
1920–1921
1921–1922
1922–1923
1923–1924
1924–1925
1925–1926

⊙ April rainfall over 6 inches.

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Plate No VII

MONTHLY PERCENTAGES OF RAINFALL AND CACAO YIELDS ON ASUANSI EXPERIMENT STATION

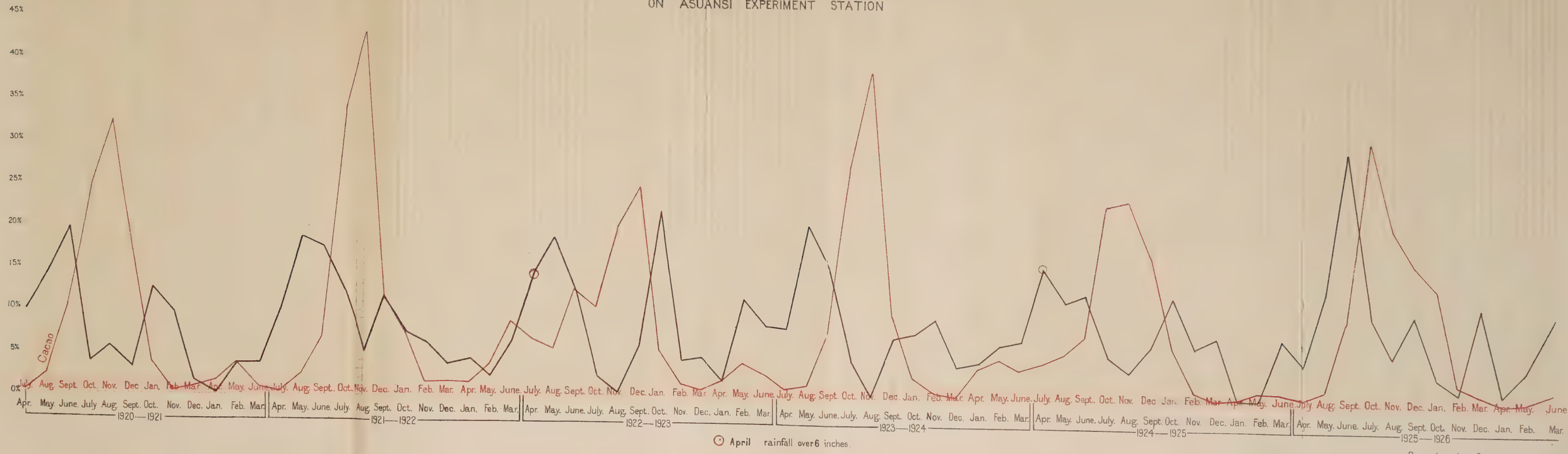

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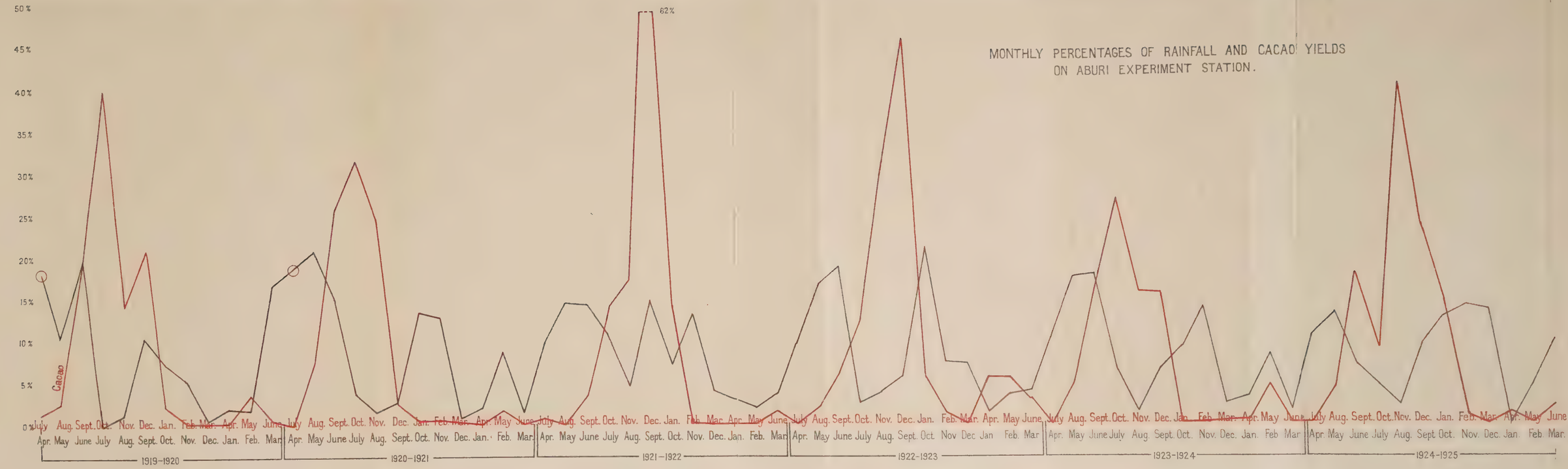
Plate Nº VIII

MONTHLY PERCENTAGES OF RAINFALL AND CACAO YIELDS ON ABURI EXPERIMENT STATION.


50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
62%
Cacao
July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June
Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar.
1919-1920
1920-1921
1921-1922
1922-1923
1923-1924
1924-1925

⊙ April rainfall over 6 inches.

Reproduced at Survey H.Q. Accra, 1928.

PAPER No. XIII.

THE RELATION BETWEEN DISEASED CUSHIONS AND THE SEASONAL OUTBREAK OF "BLACK POD" DISEASE OF CACAO.

BY H. A. DADE.

Illustrations in colour by Lynn Dade.

The disease of the bark known as "canker" does not apparently attain, in the Gold Coast, to the same serious proportions as in other cacao producing countries. It is, however, sufficiently widespread to be well known, and recent observations have shown that it is of far more common occurrence, in an inconspicuous form, than was previously known, and that it therefore bears a much more important relation to the incidence of cacao pod disease than was previously suspected.

It will be superfluous to refer in detail here to the work of well-known plant pathologists who have described canker and its cause in other countries. All agriculturists who work with cacao will be familiar with their work. J. B. Rorer, working in Trinidad, first definitely showed that canker was due to *Phytophthora Faberi*, Maub., the fungus which also causes the principal pod disease. A recent detailed account of cacao canker will be found in Nowell's "Diseases of Crop Plants in the Lesser Antilles." It was, of course, known that cushions became infected from diseased pods, and *vice versa.*

The purpose of this note is to describe in some detail the form of canker most commonly found in the Gold Coast.

In previous work (See Bulletin No. 6 of this Department) it was found that cases of "black pod" disease, caused by *P. Faberi*, occur in rather definite proportions in different regions of the pod—*i.e.*, about two-thirds of the infections occur in the proximal region, one-quarter in the lateral, and the remainder in the distal region. The factors responsible for this were discussed, but it was shown that in some cases proximal infections were derived from previously diseased cushions, and were not external in origin, though for what proportion of the proximal infections diseased cushions were responsible was not known. A study of the heaps of discarded husks which are left by farmers in their farms, and which had formerly been regarded as responsible for carrying over disease from one year to another, produced evidence that some other means of "over-wintering" must be chiefly responsible, and there was, moreover, some evidence that diseased cushions provided this means.

In 1927 a closer study of this aspect of pod disease was made. At the beginning of the season a survey of farms in Akyem and Kwahu was carried out, and it was found that the great majority of the proximal—and indeed of all "black pod" infections

which had occurred by then were definitely associated with cushions in which there was deeply seated disease. All stages of infection were seen, including cases in which infection had not yet actually reached the pod, but was travelling down the peduncle.

Small blocks of infected tissue, removed from the deeper regions of cushions by means of sterile knives, produced cultures of *P. Faberi* on corn meal agar. These cultures were more than usually vigorous, and produced a rapid rot on cacao pods within two days after inoculation.

There is therefore no doubt that *P. Faberi* can pass the harmattan* in cushions. The majority, if not all, of the earliest pod infections have their origin in diseased cushions, and there seems to be no doubt that this is the principal, as it is certainly the most effective, means of production of the seasonal activity of *P. Faberi* as a pod pathogen.

A close examination of cacao growing in Aburi agricultural station revealed no diseased cushions and no infection by *P. Faberi* as late as September. On this station all diseased pods are systematically removed as soon as they are observed, and no doubt this practice has been the means of preventing cushions from becoming infected. The infections which take place there every year—very few as compared with those in native farms—are external and probably are derived from neighbouring farms.

Dissection of diseased cushions shows that the adjacent bark is more or less involved in typical bark canker, and that the infected portions of the cushions are continuous with the cankers.

In the tissues of the peduncle and the summit of the cushion some assimilatory tissue is present, and its pale green ground colour affects the appearance of the areas recently involved in active infection. Here the discoloured tissues are of a water-soaked greyish-green colour, with reddish edges, and traversed by reddish lines. They become claret coloured with age, then black and dry. On exposure to the air the colour rapidly changes to a dull brown, but the original colour may be preserved for a short time, for examination, by immersion in water. When the peduncular trace is affected, as frequently occurs, it assumes at first a pale brown colour, and later becomes black.

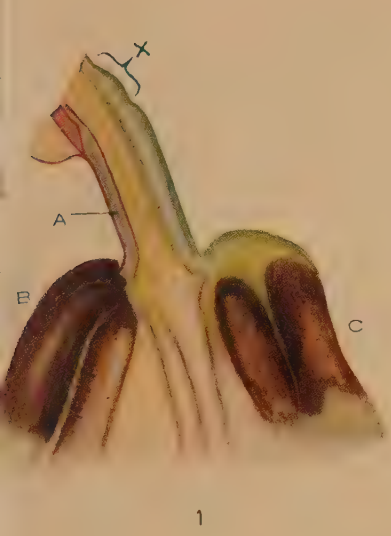
The general appearance of diseased cushions is indicated by figures 3-8 in Plate IX.

From the cushion infection proceeds into the surrounding bark. It extends only for a short distance laterally or vertically upwards, but spreads principally vertically downwards for a distance of up to five or six inches, usually two or three inches. (See figures 1-3 in Plate X.)

In previous descriptions of canker the claret colour of infected bark has been emphasized. In the cases studied by the present author the claret colour was assumed only with age. Attempts to obtain cultures of *P. Faberi* from claret coloured tissues have failed. In the tissue of active cankers the colour of the freshly

* N.B.—The harmattan is the dry wind which blows from the Sahara to the South during December and January. The word is used here to indicate the season.—*Editor.*

PLATE IX



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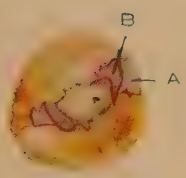

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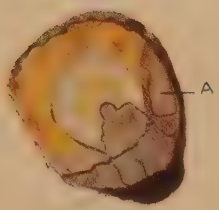

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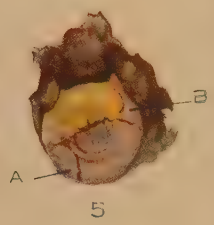

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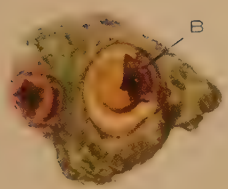

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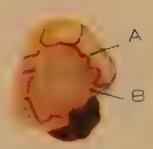

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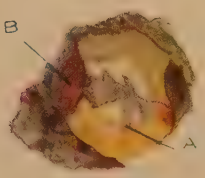

8

DISEASED CUSHIONS OF CACAO TREES.

Figs. 1, 2.—Infection of pods from diseased cushions. A—Diseased tissue of peduncle containing active mycelium. B—Site of first appearance of disease on surface of pod. C—Opposite side of pod reached by lateral circumferential spread. X—"Basal part" of peduncle.

Figs. 3–8.—Appearance of diseased cushions after removal of summit. A—Tissue containing active mycelium. B—Older part of infection.

PLATE X.

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5

SECTIONS OF DISEASED CUSHIONS.

Figs. 1–3.—Bark cankers continuous with diseased cushions. Outer bark removed in 1 and 2, partly removed in 3. A—Recently invaded tissue containing active mycelium. B—Older infected tissue. T—Peduncular trace.

Figs. 4, 5.—Small cankers in bark caused by contact between shoulder of diseased pod and trunk. Outer bark removed.

exposed diseased bark is a pale maroon with brighter reddish brown edges. Close examination shows that the general colour is largely due to the numerous wavy red lines which mark the limits of growth periods of the fungus. The true ground colour is difficult to describe and to reproduce in illustrations. The whole area is water soaked, which deadens and obscures colour, and the appearance of the tissue between the darker zone lines is a sort of very pale pinkish fawn. After a short exposure to air the whole of the diseased surface darkens rapidly to a deep claret colour, and the network of fine zone lines disappears.

The downward extension of the canker is narrow, but penetrates through the bark and blackens the wood.

Small cankers often occur in bark just below the cushions where diseased pods growing from the cushions are in contact with the trunk. (Figures 4, 5, Plate X.) These small cankers do not normally spread, and have not been found to infect cushions above. Normal extension of canker growth seems to be vertically downwards. It is possible that some cases of lateral infection of pods may take place from such cankers in succeeding years.

In a few cases, cushions were found to be infected from previously infected cushions immediately above them.

Pod infection due to diseased cushions cannot be readily diagnosed by inspection. Active cankers cannot be found by examining the outer bark, which shows no trace of their existence until they are old, when the bark cracks and exudation of sap occurs before the final desiccation. The existence of diseased cushions can, however, be discovered, when a proximally infected pod is seen, by lightly scraping the peduncle with a knife or the finger nail. The brown cuticularised layer is thin and easily removed, and in a healthy case bright green assimilatory tissue is exposed. On the summit of the cushion the colour of the exposed surface is green to cream. It may be necessary, in a fresh infection, to examine the complete circumference of the peduncle, but it is usually sufficient to scrape it on the side where the pod infection has progressed most.

If the pod has been infected externally, the peduncle shows no discolouration unless the infection is an old one and the pod is completely involved. Even then discolouration frequently does not proceed into what Van Hall calls the "basal part" of the peduncle—*i.e.*, the part which forms the cushion of the following year. (Figure 1, x, Plate IX.) When the basal part is invaded the cushion is definitely infected.

In the case of infection proceeding *from* the cushion removal of the cuticle of the peduncle shows a greyish green area with reddish edges, traversed by red lines, and this may be traced by further scraping into the cushion. In older infections the peduncle is dry and brown.

(The use of stainless steel scalpels in the critical dissection of cacao tissues is advantageous.)

Infection usually travels down one side of the peduncle—that side adjacent to the diseased part of the cushion. The fungus

reaches the pod at the insertion of the peduncle, and proceeds to the surface of the shoulder of the pod. It spreads more rapidly laterally than vertically, and quickly reaches the opposite side of the pod. (See figure 1 in Plate IX.) The five vascular strands which lie in the axis of the pod are very soon affected and blackened. Infection continues to spread more rapidly through the cortical tissue, however, and not via the vascular system.

In normally healthy trees cankers found in connection with diseased cushions do not attain to great dimensions. Five or six inches is about their maximum length. Extreme cases of very serious bark injury are not very common in the Gold Coast. Occasionally farms are found where serious cankers exist and where large areas of bark are involved, but all such cases as have been seen have been associated with environmental conditions unfavourable to the constitution of the host. It is, in fact, probable that the relative unimportance of bark canker, as far as injury to the bark is concerned, in the Gold Coast as compared with other countries, may be due to the remarkably favourable conditions for cacao culture which exist here.

In the areas in which diseased cushions were studied in 1927, environmental conditions are such as favour a large incidence of pod disease, and are also favourable for cushion and bark infection, but the trees are in normal health. Under such conditions recovery is the rule. The complete history of the cushion infections is not definitely known—it is not possible to investigate the course of the attack and at the same time to preserve the case, as no external symptoms are demonstrated until the advance stage ensues. But so far as can be made out, infection normally takes place from a diseased pod, via the peduncle; thence it spreads to the bark and extends below the cushion for five or six inches. The active stage probably continues over a period of two or three years, during which time pods borne on the cushion are infected. Finally, the cushion becomes so completely involved that fruit production ceases. Extension of the adjacent bark canker ceases at about the same time, or perhaps a year later. The dead bark rots away, and is often removed by ants, which make temporary shelters in the cavities thus formed. The outer bark cracks, dries and curls inwards into the cavity. The cushion also decays and is represented by a shell of dried outer bark and fragments of peduncles. (Figure 1 in Plate XI.) Cambial regeneration begins immediately the canker ceases to spread, and cambial folds roll laterally inwards below the dead outer bark, which is forced outwards. Removal of this outer bark from what appears to be a serious lesion now displays a completely or almost completely renewed bark. (Figure 2 in Plate XI.) Recovery seems to be rapid.

Single trees may be seen with dozens of cankers in all stages, from primary infections to complete recoveries. In other cases, trees which do not fruit in a particular season may be found to be in a state where every cushion has reached the stage of destruction, and cambial activity apparently absorbs the resources of the tree. Such cases are rare.

1

2

CANKERED CACAO TREES.

Fig. 1.—External appearance of cushion which has been destroyed, with bark canker below. Bark dry, discoloured and cracked.

Fig. 2.—Recovery. Part of old outer bark removed to show new bark covering old canker.

PAPER No. XIV.

A COMPARISON OF THE PATHOGENICITY OF VARIOUS STRAINS OF *PHYTOPHTHORA FABERI*, MAUBL., ON CACAO PODS, ETC., IN THE GOLD COAST.

By H. A. DADE.

This work was undertaken at the request of Professor S. F. Ashby, of the Imperial Bureau of Mycology, at whose disposal the information obtained has been placed.

Many strains of *Phytophthora Faberi* exist, causing diseases in a wide range of tropical crops, and the affinity of these several strains is not yet clear. Sexual reproduction takes place only when certain strains are grown in mixed culture with other strains or with other species of Phytophthora, as was first shown by Ashby ("Oospores in cultures of *P. Faberi*," Kew Bull., p. 257, 1922).

The present work provides information which may assist in throwing light on the affinities of the various parasitic strains in question, by demonstrating their relative pathogenicity on cacao pods.

The strains used, the first nine of which were supplied by Professor Ashby, were:—

1. Coconut bud rot, Jamaica.
2. Palm, India, sent from Pusa to the Department of Agriculture, Federated Malay States, and thence to Imperial Bureau of Mycology in 1926
3. Hevea black thread, Federated Malay State, sent to Imperial Bureau of Mycology in 1926 by A. Thompson.
4. Sea Island Cotton boll-rot, St. Vincent (Ashby).
5. Cacao pod-rot, Trinidad.
6. Mimusops fruit rot (Gold Coast) sent to Imperial Bureau of Mycology in 1924 by the present writer.
7. Cacao pod-rot, Philippines (Reinking's) strain, obtained by Imperial Bureau of Mycology from the Bearn Collection, Holland.
8. Citrus blight, Philippines (Ocfemia).
9. Cacao pod-rot, Gold Coast, sent to Imperial Bureau of Mycology in 1925.
10. Cacao pod-rot, fresh isolation, Gold Coast.

Unfortunately the numbers of infections studied were small owing to the limitations of laboratory facilities, but the results show at least some definite facts.

Twenty Criollo and twenty Amelonado pods were used in artificial inoculations with each strain of *P. Faberi*. Half of these were wounded with a knife point, the other half were intact. The pods were kept in a saturated atmosphere in desiccators. Temperature varied between 75° and 82° C.

Results are shown in the table.

Strains 3, 4 and 8 are evidently not able to parasitize cacao pods.

Strain 6, when freshly isolated in the Gold Coast by the writer in 1924, was a rather feeble wound parasite. After being in artificial culture since 1924, it appears to have lost its pathogenicity. (This strain was found causing a fruit fall and rot in Mimusops (Elengi?) at Aburi).

Strains 1 and 2 are rather doubtful wound parasites.

Strain 7 was received as Reinking's strain of *P. Faberi*, causing cacao pod rot in the Philippines. If its source is authentic it would appear to be an abnormal culture, for it is evidently only very feebly parasitic, and after such a long delay in growth may have been only growing in necrotic tissue.

Strain 5, the Trinidad cacao pod organism, is undoubtedly identical with the Gold Coast form.

The Gold Coast culture (strain 9) was sent to Imperial Bureau of Mycology in 1925, and has been in artificial culture since then. It was distinctly less virulent than the fresh isolation (10).

The present writer obtained oospores by growing strains 6 and 9 on cacao pods, and therefore attempts to obtain oospores on Hevea pods and cotton bolls were made as follows:—

Hevea.

Strain 3 *alone.*—(Check) 6 pods were inoculated.

Discolouration began after 3 days in each case.

Sporulation in all on the fifth day.

Strains 3 *and* 2, 3 *and* 5, *and* 3 *and* 9.—Six pods were used in each double inoculation.

Strains 2, 5 and 9 grew much more quickly than 3, which was completely overgrown, strain 5 being the most rapid in spread. No oospores were found.

Cotton Bolls.

The only Egyptian cotton available was a bastard strain originally imported into Togoland by the German authorities.

Strain 4 *alone.*—(Check) 12 bolls were inoculated.

Discolouration began after two days and spread rapidly.

Aerial mycelium was produced and sporulation began on the third day.

Strains 4 *and* 2, 4 *and* 5, *and* 4 *and* 9.—12 bolls were used in each double inoculation. All were discoloured after two days, and all were in an advanced stage of decay after five days. No oospores were found.

Strain.	AMELONADO.		CRIOLLO.	
	Wounded.	Unwounded.	Wounded.	Unwounded.
1. Jamaica Coconut Bud-rot.	1/5 + ve. Discolouration began after 2 days, stain 1″ diam. after 6 days. Pods completely involved after 10 days. Chlamydospores after 8 days on ærial mycelium. Before this, only sporangia.	All —ve	1/5 + ve. As for Amelonado.	All —ve.
2. Palm, India ..	2/5 + ve. Slight discolouration after 7 days, reaching diameter of 2″ after 14 days. Scanty sporulation. Swamped by secondary contaminations of saprophytes.	All —ve	4/5 + ve. As for Amelonado.	All —ve.
3. Hevea, F.M.S. Black Thread.	———— All —ve ..	10 days after inoculation.		
4. Cotton Boll-rot, St. Vincent.	———— All —ve ..	16 days after inoculation.		
5. Cacao Pod-rot, Trinidad.	5/5 + ve. Discolouration began 2 days after inoculation. Pods completely involved after 7 days. Sporangia and chlamydospores.	1/5 + ve. Discolouration 2″ in diameter after 7 days. Pod completely involved after 12 days.	5/5 + ve. As for Amelonado.	2/5 + ve. Discolouration 1″ and 2½″ diam. after 7 days. Pods completely involved after 12 days.

Strain.	AMELONADO.		CRIOLLO.	
	Wounded.	Unwounded.	Wounded.	Unwounded.
6. Mimusops, Gold Coast	———— All —ve ..	12 days after inoculation.		
7. Philippines, Cacao (Reinking).	1/5 + ve. After 10 days. Sporangia and chlamydospores formed.	All —ve	All —ve	1/5 + ve. After 10 days Sporangia and chlamydospores formed.
8. Philippines, Citrus (Ocfemia).	———— All —ve ..	15 days after inoculation.		
9. Gold Coast, Cacao (I.B.M.).	5/5 + ve. Discolouration began 2 days after inoculation. Pods completely involved after 9 days. Sporangia and chlamydospores.	2/5 + ve. Discolouration began after 8 days. Pods completely involved after 16 days. Sporangia and chlamydospores.	5/5 + ve. As for Amelonado.	All —ve.
10. Gold Coast, Cacao (Fresh Isolation).	5/5 + ve. Discolouration began 2 days after inoculation. Pods completely involved after 7 days. Sporangia and chlamydospores.	4/5 + ve. In 3 pods discolouration after 6 days. Pods completely involved after 11 days. In 1 pod discolouration after 8 days, whole pod involved after 13 days.	5/5 + ve. As for Amelonado.	4/5 + ve. In 2 pods discolouration after 5 days. Pods completely involved after 10 days. In 2 others discolouraation after 8 days, completely involved after 13 days.

PAPER No. XV.

DISSEMINATION OF CACAO POD DISEASES BY INVERTEBRATES.

By H. A. DADE.

Early in the 1927 season a rather unusually large number of cases of " Mealy Pod " were observed on some trees in a cacao plot in the Aburi agricultural station. Distribution through the plot was very uneven, and could not be correlated with the usual determining factors. The few particular trees affected showed a very high percentage—25 to 68—of infections.

Close observation showed that these trees were infested by ants, which were eating the conidia of *Trachysphæra fructigena*, Bunt. and Tabor, and in some cases carrying away masses of conidia. Two species were found behaving thus—(i) a small brown species, which was also herding coccids, and living in temporary shelters in crevices or under leaves at the base of the tree; (ii) a larger black species. The latter also damages pods by removing the epidermis, which is used in the building of large arboreal " carton " nests. They have not yet been identified, but belong probably to the genus *Crematogaster*. (Some members of this genus cultivate fungus gardens, but these have not been found in the case of the two species under discussion.)

The transportation of spores by ants forms an effective means of dissemination of pod disease, and when damage to the pods also takes place infection is facilitated. The debris which ants eject from their mouths is known to contain fungus spores which have been removed from their limbs in the process of cleaning, which is performed by the mouth.

A small flat snail is rather common in cacao farms and has been seen feeding on spore masses of *T. fructigena*. One of these snails was fed on a " mealy pod " in the laboratory, and the excrement was found to contain large numbers of viable spores, which germinated in hanging drop cultures, and which produced mealy pod disease when inoculated into pods.

These two cases serve to indicate the large though inconspicuous part which insects and other small invertebrates undoubtedly play in the transmission of pod diseases.

PAPER No. XVI.

THE RED BANDED CACAO THRIPS, HELIOTHRIPS RUBROCINCTUS, GIARD.

By G. S. COTTERELL.

The red banded cacao thrips, *Heliothrips rubrocinctus*, Giard, has been known to attack cacao in the Gold Coast for a considerable time. It has a large number of other food-plants and no doubt occurred on these before cacao was introduced.

The adult is a small black suctorial insect about one-sixteenth of an inch in length with two pairs of narrow wings fringed with hairs. The wings are carried folded up over the abdomen when not in use. (Plate XII, figs. 1 and 2.)

The nymphs are yellow with a red band extending across the dorsal surface of the first two abdominal segments. Except in the two final nymphal stages six long black hairs project from the final abdominal segment and these support a drop of fluid which consists of excrement which is carried about by the nymph (Plate XII, figs. 4 and 6) until surface tension is overcome and the drop falls on the leaf or pod forming a brown blotch when dry.

Damage is caused by the nymphs and adults sucking the lower surface of the leaf or surface of developing pods. The epidermal cells are broken down and in severe cases of leaf damage this is followed by general necrosis of the attacked area and subsequent abscission.

Leaf damage is much more serious on young trees than established trees.

H. rubrocinctus is known as a pest in all cacao-producing countries, and in some places as a pest of major importance. In San Thomé enormous damage is attributed to this insect [ref. Patterson, in Thrips in San Thomé (1)]. In the Gold Coast it cannot at present be called a major pest, but the conditions favourable to the development of this pest are becoming more and more common and it is possible that it may become of major importance in the near future. In this country, attack is found to occur under three bad cultural conditions which can all be correlated with faulty water relations between plant and soil, otherwise conditions that are not favourable to the growth of cacao. These three conditions are (i) low or irregular humidity, due to indiscriminate deforestation, (ii) exposure of plant and soil to sun and wind, *i.e.*, absence of overhead and lateral shade, (iii) soil of a low water retaining power. It is only in areas where the above conditions exist that Thrips attack is found.

PLATE XII.

Fig. 1.

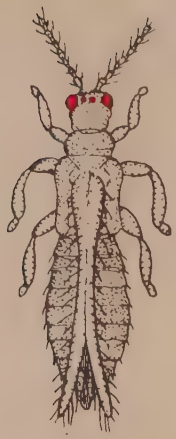

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

The Red Banded Cacao Thrips. (Heliothrips rubrocinctus.)

Figs. 1 & 2. Adult stage. Fig. 3. Pupal stage.
Figs. 5 & 6. Nymphal stage.

Both the under side of the foliage and the surface of the pods are attacked. The former is the less serious of the two as only the outer skin of the pericarp is effected so that the pod develops normally. Pods are not attacked until within a few weeks of maturity. It is difficult to ascertain when attacked pods are mature as the whole surface becomes rust coloured. By scraping the epidermis of an attacked pod the familiar yellow colouring indicating maturity can be observed. Naturally, therefore, a number of attacked pods are reaped either before or too long after maturity resulting in a lowering in quality of the ultimate product owing to the mixing of immature or over-mature beans.

Damage to foliage is much more serious, as attacked leaves are as a general rule abscissed, resulting, in severe cases, in complete defoliation. Attack is confined to the under surface of the leaves. Occasionally, succulent leaves are attacked, but normally, attack is confined to the older leaves.

Abscission followed by die-back resulting from Thrips attack also follows purely physiological conditions, chiefly bad water relations, that are unfavourable to the growth of cacao. In the past, a very large amount of this die-back has been credited to Thrips. This is not the case. For this reason, as far as this country is concerned, Thrips can be classed for the present as a minor pest, as it is entirely secondary to bad cultural conditions. Where Thrips is found as a pest, attacks are found to be periodic corresponding with conditions where physiological die-back is expected to occur.

These conditions consist of abnormal periods of drought or heavy rainfall in areas where shade and soil conditions are not suited to the growth of cacao. In the Gold Coast at the present time all years are climatically abnormal when compared with the conditions under which cacao was originally established.

H. rubrocinctus has a wide range of food plants in this country. Among those recorded so far are:—

Cola acuminata.
Mango. (*Mangifera indica.*)
Guava. (*Psidium guayava.*)
Avocado. (*Persea gratissima.*)
Acalypha sp.
Terminalia sp.

There are many others in addition. In San Thomé *Claoxylon molleri Copaifera mopane*, *Manihot utilissima*, *Pseudospondias microcarpa*, *Psidium pomiferum*, and *Urophyllum insulare* are listed as food plants by De Seabre (2).

In 1925 the life history of *H. rubrocinctus* was roughly worked out at Asamankese in Akim-Abuakwa when the writer was working on other pests of cacao. Difficulty was found in improvising a suitable type of cage in which the insects could be confined and the various stages observed. It was found necessary to cage the insects on the plant in the field. Eventually, a cage was made consisting of a cover of an entomological pill box with the glass

removed and replaced by a double layer of fine cotton gauze. An inside wall of cardboard was made and the space between the two walls packed with cotton wool so that, when clamped to the under surface of a cacao leaf, no space was left between the leaf veins through which the insects could escape. A number of these cages were put out and were found to be more or less satisfactory, but even so a large number of insects escaped. Twenty to thirty adult Thrips were confined in each of these cages and left one day, after which they were removed. It was thus possible to ascertain roughly the incubation period of the egg and length of the subsequent stages. The incubation period was found to average one to three days. Reyne (3) states that in Surinam he found the incubation period to be as long as 10 to 13 days at 68°-86° F. Urich (4) gives the incubation period in Grenada as from three to four days. It is probable that the incubation period varies considerably in different parts of the world and at different periods of the year. The eggs are deposited singly in the under surface of the leaves usually adjacent to a leaf vein and also in pods and covered with a drop of excrement. They are bean-shaped and translucent. The nymphal life was found to vary from twelve to thirteen days during which time there are four moults. The feeding period averages seven days, during which there are two moults, the second being followed by the so-called pre-pupal stage. (Plate XII, fig. 5.)

During the feeding period the nymph is exceedingly active, and is characterised by six long black spines that project from the final abdominal segment. These spines support a drop of excrement which periodically falls off forming brown blotches on the pod or leaf. In this stage the abdomen is curled upwards at the tip so that the drop is carried over the abdomen. In the pre-pupal period these hairs, and therefore drop, are missing. Feeding ceases and the nymphs are comparatively inactive. The wing lobes have commenced to appear as two extensions from the thoracic segments. This stage lasts approximately three days and the nymphs tend to congregate together usually at the proximal end of the leaf. Another moult occurs and the so-called pre-pupal stage is reached. (Plate XII, fig. 4.) In this stage the nymphs are inactive, but move if disturbed. The pupal period is characterised by a change in colour, becoming more opaque due to the development of fat. It can be distinguished from the previous stage by the larger wing lobes and by the antennæ, which in this stage turn back over the head whereas in the previous stage they project forward.

The pupal stage averages three days in length when a final moult occurs and the winged adult is produced. In Grenada, Urich (4) states that the feeding period lasts about nine days and the pre-pupal and pupal stages 24 hours and 48 hours respectively. In Surinam, Reyne (3) gives the feeding period as 9 to 10 days, the pre-pupal 24 hours and the pupal two to three days.

At Asamankese all adults examined were found to be females, but no large count was made. The adults are parthenogenetic, but probably a few males are produced occasionally. In Surinam, Reyne (3) states that out of a count of 30,000 only 0.26 per cent. were males. The highest percentage of males was 1.5 per cent. in the case of a severe infestation.

Reyne (3) states that the maximum number of eggs oviposited by one female was 87.

The adult has two pairs of narrow fringed wings and appears to be incapable of long direct flight. Flight consists chiefly of hops from leaf to leaf. Although Thrips are found infesting cacao growing in exposed situations direct sunlight is avoided. This is more marked with nymphs than adults.

Natural enemies of *Heliothrips rubrocinctus* in this country consist of (1) a predaceous Thrips, (2) small spiders, and (3) an internal Hymenopterous parasite. The predaceous Thrips has not yet been determined. Nymphs and adults are occasionally found amongst *Heliothrips* colonies. It is of no importance as a check. Small spiders, which spin their webs over the undersurface of the leaves and live chiefly at the expense of Thrips, appear to form an important check. There appears to be a kind of symbiosis between these spiders and their prey, as the latter invariably collect under these webs presumably for protection from other predators, during the pupal and pre-pupal periods. The effectiveness of these spiders as a control is somewhat neutralised by the fact that a number of adult parasites emerging from parasitised nymphs are undoubtedly caught in the webs and destroyed.

The hymenopterous parasite is exceedingly minute. Emergence takes place from the pre-pupal or pupal stage of the host. Details of this parasite have already been published as far as known by the writer (5) in the 1926 Year Book, pp. 47-48. Parasitism has reached as high as 80 per cent. following periods of heavy infestation.

There is no record of a parasite emerging from the nymphal stages in other countries in which Thrips occurs.

A Scelionid egg parasite, *Baryconus* sp., has been recorded by Bondar (6) in Brazil.

It is possible that the presence of the nymphal parasite in this country is a reason why Thrips is not so prevalent a pest as in other cacao-producing countries.

This parasite may be of considerable use in the Island of San Thomé if it does not already occur there.

According to Reyne (3) natural enemies of Thrips in Surinam include two species of a Chrysopid larvæ and a *Cephalosporium* fungus. Urich (4) states that in Grenada a species of lace-wing fly (Chrysopid) and in Trinidad several species of Reduviid bugs exercise some measure of control, but that these do not confine themselves to Thrips and generally appear after the worst damage has been done. An entomogenous fungus, *Sporotrichum globuliferum*, has been observed to attack Thrips in Barbados, but is stated to be of little use as a control.

As Thrips attack always follows certain cultural conditions that are unfavourable to the growth of cacao, correction of these conditions is obviously the only line of control. These measures therefore are (i) the prevention of indiscriminate deforestation, (ii)

the provision of adequate overhead and lateral protection to farms where these have been removed, and (iii) improvement of soil conditions by draining and manuring if practicable. In a number of areas it is impossible to correct these conditions. However, as these conditions are unfavourable to the growth of cacao, causing physiological die-back, these areas should be abandoned as far as attempting to establish new cacao is concerned. It may be that already established cacao growing in these areas may be doing fairly well having been established under entirely different conditions. In these areas pod damage is the most serious and leaf damage comparatively small. In these cases attack on pods will start up as soon as a hole is made in the overhead shade exposing the soil. Pods on surrounding trees will become heavily infested with Thrips following any abnormal climatic condition. The same will happen when lateral protection is removed. In these cases the protection should be replaced.

In this country, artificial controls such as the use of sprays or dusts are impracticable at any rate as a measure against Thrips. Reyne (6) in Surinam stated that a spray consisting of a wash of 2 per cent. milk of lime in water was effective. Kaolin was found to be more effective, but it is difficult to distinguish between treated and untreated trees. This type of spray is purely protective. While the writer was experimenting with lime-sulphur wash at Asamankese it was found that the deposit of lime and sulphur left on the foliage remained a considerable time and had the effect of keeping Thrips away whilst it was present.

SUMMARY.

1. The Red-banded Cacao Thrips, *Heliothrips rubrocinctus* Giard has been known in the Gold Coast for a considerable time.

2. Damage is caused by the adults and nymphs sucking the under side of the leaves and pods. In the former case, general necrosis of attacked areas follows, and in severe cases the leaf is abscissed.

3. Leaf damage is more serious on young trees.

4. Attack occurs under conditions that are unfavourable for the development of the cacao plant, *i.e.*, bad soil, lack of shade and lateral protection.

5. Damage is found to be secondary, as damage always occurs in areas where physiological die-back is prevalent.

6. A list of the major food plants is given.

7. The eggs are deposited singly in the under side of the leaves and in pods and all subsequent stages are laid on the plant. The incubation period was found to average one to three days.

8. The feeding period averaged seven days, the pre-pupal three days and the pupal period three days.

9. Parthenogenesis occurs. All adults at Asamankese were found to be females. It is possible that occasionally a few males are produced.

10. Natural enemies consist of a predaceous Thrips, small spiders and a Chalcid parasite which emerges from the pre-pupal or pupal stage.

11. Cultural methods of control consist of the correction of the conditions favourable to Thrips attack.

12. Artificial controls are impracticable in this country, but it has been ascertained that the application of a 2 per cent. solution of lime or kaoline acts as a preventative against oviposition.

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PAPER No. XVII.

MINOR PESTS OF CACAO.

By G. S. COTTERELL.

Sucking Insects.

Details of the life-history and habits of the pests listed below have been worked out in conjunction with investigations into the life-history and habits of *Sahlbergella* spp. at Asamankese in Akim-Abuakwa in 1925.

Helopeltis bergrothi, Reut.

Helopeltis bergrothi, known locally as "Cacao Mosquito," although having no relation to the Culicidæ, is a Capsid bug which damages cacao by puncturing the pericarp of maturing pods. It also occasionally damages the herbaceous shoots of young cacao.

The adult (Plate XIII) is a slender insect a little over one centimetre in length, green in colour, with red markings. A large spine tipped with red projects from the dorsal surface of the thorax. The legs are long and spidery.

The eggs are laid in the cushions and peduncles of maturing pods and occasionally in the pods themselves. They are approximately two millimetres in length, elongate, curved and milky white when newly laid. They are embedded in the tissue of the plant, leaving two fine filaments projecting similar to those of *Sahlbergella* spp. (1) but more elongated. One day after oviposition these filaments turn back away from each other and for this reason are distinguishable from those of *Sahlbergella*. (Plate XIII.) The eggs hatch after a period of 14 days. The newly-hatched nymph is green in colour and has no thoracic spine. This is developed in the second instar and remains in the succeeding instars. The second nymphal instar is characterised by the appearance of red markings on the dorsal surface of the abdomen. These become more prominent in later instars. Wing lobes appear in the third instar period. There are five moults before the adult stage is reached. The nymphal life averages 19 to 20 days, the minimum period observed being 17 days and the maximum 22 days, the life from egg to adult averaging 33 to 34 days. One or two days prior to the final moult the wing lobes turn black.

The nymphs do not necessarily prefer shaded situations, and therefore punctures are found on all parts of the pod, and not concentrated as in the case of *Sahlbergella* spp., where feeding is confined to the underside of pods.

Although one adult is capable of making as many as 100 punctures per day, little damage is caused. As stated previously, very rarely other than maturing pods are attached. The punctures do not go to a depth of more than two to three mm. An area of about one mm. in radius around each puncture dies, and a corky scab

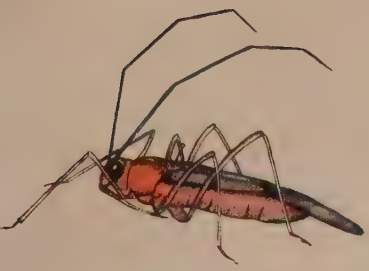

Fig. 1.

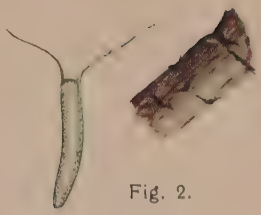

Fig. 2.

Fig. 3

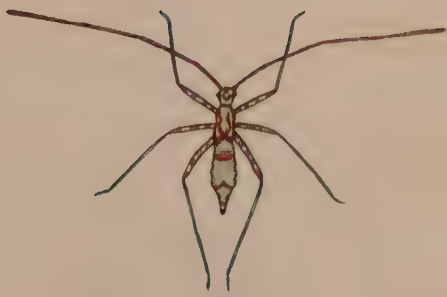

Fig. 4.

Fig. 5.

Cacao Mosquito (Helopeltis bergrothi Reut.)

Fig. 1. Adult.
Fig. 2. Egg enlarged and eggs in situ in pod peduncle.
Fig. 3. Pod damage by adult and Nymphs of Helopeltis.
Fig. 4. Third instar nymph.
Fig. 5. Fifth instar nymph.

is quickly formed, thus lessening the chances of infection by pod disease. Very occasionally young pods may be attacked, causing mal-formation and possible abortion.

Damage to herbaceous shoots is of very rare occurrence. Only one case has been observed by the writer, and that at Asamankese, in 1922, on cacao one to two years old. The area in which this cacao was growing had been cleared of all vegetation before planting. Secondary growth consisted chiefly of a species of *Ipomœa*, an alternative food plant of *Helopeltis*. *Helopeltis* was breeding on this and the adults doing a certain amount of damage to the young cacao. On one occasion an attempt at oviposition in a young cacao tree about four years old was observed. The egg was not fully inserted in the herbaceous shoot and did not hatch.

From experiments carried out on the longevity of *Helopeltis* adults, it was found that adult females could live in captivity for as long as six weeks. One adult was kept alive for 39 days and at the end of this period appeared to be as healthy as ever. Records could not be carried further, as cessation of other work resulted in all records being closed down at Asamankese. During this period 20 ovipositions were observed at practically daily intervals. In all, 126 eggs were laid, the most at one oviposition being 16. It is probable that a very much larger number of eggs are laid by one female as Patterson (2) states that he has kept females alive for as long as 70 days.

A period of seven days elapses between the final ecdysis and first oviposition.

A large number of alternative food plants of *Helopeltis* has been listed. Patterson (3) lists 60 odd species of plants representing 20 natural orders. Most of these are imported plants and ornamental. Probably the most important food plants in the cacao growing areas are *Ipomœa* spp., *Acalypha* spp., and *Capsicum* spp., and a number of species of Malvaceæ and allied orders. *Helopeltis bergrothi* also attacks cotton and can be a serious pest of this plant. The question of soil conditions obviously plays an important part in attack on alternative food plants. Whereas in one area one species of plant will be readily attacked, in another *Helopeltis* cannot be made to feed, but will readily feed and breed on another, and *vice versa*.

Andrews (4), working on Tea *Helopeltis* in India, stated that there appeared to be a relation between the chemical composition of the soil and the amount of *Helopeltis* attack. Whether the same applies here has not been ascertained. In the writer's opinion it is much more probably due to physical soil conditions.

Helopeltis attack on cacao is found throughout the cacao belt, where conditions are favourable for its attack occur. These conditions are poor water retaining power of soil, shallow soil and lack of shade. All these conditions result in undue variations in humidity in the area in which the cacao is growing. It can therefore be said that *Helopeltis* prefers areas where humidity is low or variable throughout the year. *Helopeltis* attack is not commonly found in areas where pod diseases are common, and

therefore the risk of secondary infection by pod disease is low. In areas where cacao is growing under conditions favourable to attack the overhead shade may be sufficiently dense to preserve the ground humidity. However, as soon as a hole is made in the canopy of shade, attack at once commences on the pods of the surrounding trees.

Natural controls of *Helopeltis* are few. Ants prey on the nymphs to a considerable extent. A Hymenopterous parasite of the nymphs has been observed, but has not yet been bred out. The degree of parasitism is unknown, but is not high. Lean (5) working on *Helopeltis bergrothi* attacking cotton in Nigeria, has bred out a Braconid parasite from the nymph, namely, *Euphorus* (?) *nigricarpus*. It is possible that this is the same parasite that occurs in the Gold Coast. Lean also records the larva of a Syrphid fly which attacks the nymphs at the time of ecdysis. No Syrphid predator has been observed attacking *Helopeltis* on cacao.

Cultural controls consist of the replacement of overhead shade and the filling up of holes in the top canopy of foliage with temporary shade such as Plantains or *Gliricidia*. Young unestablished cacao growing in obviously unsuitable areas should be destroyed.

Artificial controls are impracticable and at present unwarranted.

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Cacao Aphis.

Cacao aphis, *Toxoptera aurantia* Boy. (Plate XV, fig. 1), attacks herbaceous foliage only and cannot live on mature leaves. It is commonly found on the under surface of succulent leaves produced by young cacao following other insect attack and on the suckers put out from the trunks of mature cacao trees when these are left unpruned.

Infestation commences from the progeny of one winged individual. A number of asexual generations are produced until the foliage hardens when a winged generation of females is produced and these migrate elsewhere. Reproduction is parthenogenetic, but it is probable that males are occasionally produced. No males have been observed by the writer.

The number of days of nymphal life from birth of nymph to winged or unwinged adult was found to average seven days.

Fig. 1.

Fig. 3.

Fig. 2.

Fig. 6.

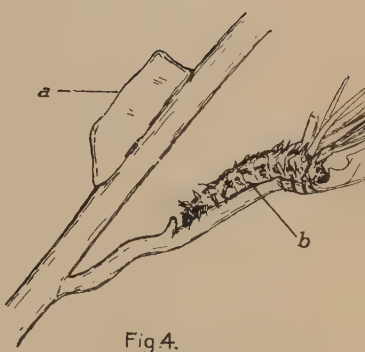

Fig 4.

Fig. 5

Fig. 7.

Fig. 8

MINOR PESTS OF CACAO.

Fig. 1.—Earias biplaga. Wlk. (Female.)

Fig. 2.—Earias biplaga. (Male.)

Fig. 3.—Egg of Earias biplaga on stipule of leaf-bud.

Fig. 4.—(*a*) Cocoon of Earias biplaga.
(*b*) Full-grown larva of Earias biplaga.

Fig. 5.—Diacrisia rattrayi. Roths.

Fig. 6.—Cocoon of parasite of Earias biplaga.

Fig. 7.—Adult parasite of Earias biplaga.

Fig 8.—Hyperparasite of Earias biplaga.

PLATE XV.

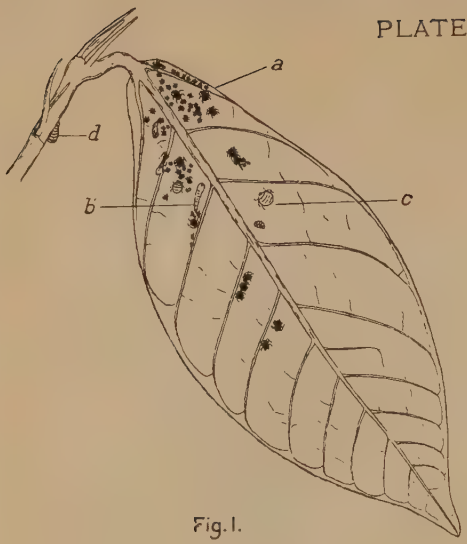

Fig. 1.

Fig. 2.

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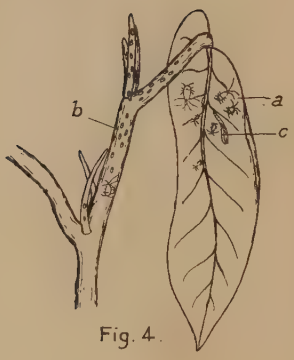

Fig. 4.

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Fig. 7.

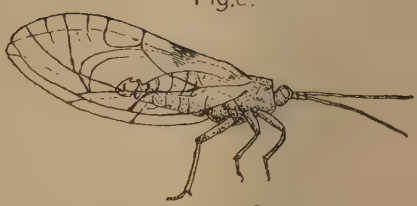


Fig. 8.

MINOR PESTS OF CACAO.

Fig. 1.—Cacao Aphis. (Toxoptera aurantia Boy.)
(*a*) Nymphs and unwinged females.
(*b*) Larva of Paragus sp. feeding on Aphis colonies.
(*c*) Larva of Novius sp. feeding on Aphis colonies.
(*d*) Cocoon of Paragus sp.
Fig. 2.—Baccha sinuata. Brun.
Fig. 3.—Novius sp.
Fig. 4.—Cacao Psyllax. (Mesohomotoma tessmanni. Aulm.)
(*a*) Nymphs. (*b*) Egg pits. (*c*) Larva of Baccha sp. feeding on nymphs.
Fig. 5.—Paragus marshalli. Bezzi.
Fig. 6.—Paragus borbonicus. Macq.
Fig. 7.—Nymph of Mesohomotoma tessmanni. Aulm. (Enlarged.)
Fig. 8.—Adult of Mesohomotoma tessmanni. Aulm. (Enlarged.)

The number of nymphal stages was not ascertained. An extra nymphal instar bearing wing lobes is produced prior to the production of a winged adult. Colonies are attended by a species of black ant.

Natural enemies are common. The most important of these are the larvæ of two Syrphid flies which prey on the colonies, namely, *Paragus marshalli*, Bezzi. (Plate XV, fig. 5), and *P. borbonicus* Macq. (Plate XV, fig. 6), and a Coccinnellid beetle, *Novius* sp. (Plate XV, fig. 3), the adults and larvae of which also are predaceous.

Except when attacking suckers put out from trunks of mature trees, attack is secondary to bad cultural conditions or secondary to other insect attack, and depends on flushes of new foliage following unfavourable climatic conditions. In the latter case control consists of removal of the pre-determining cause.

Attack is not sufficiently serious to justify artificial methods of control, even if these were practicable.

Cacao Psylla.

Cacao Psylla, *Mesohomotome* (*Udamostigma*) *tessmanni Aulm.* (Plate XV., figs. 7 and 8), also attacks herbaceous foliage only and cannot survive on mature leaves. Nymphs and adults suck leaf buds and succulent leaves produced by young cacao usually following other insect attack. Severe attack results in shortening of the internodes and consequent bunching of foliage.

The adult measures about half a mm. in length, with two pairs of membranous wings sloped over the abdomen. They are incapable of sustained flight, but hop from leaf to leaf, using the wings as planes. The hind legs are stout and used for jumping.

Eggs are laid in the bracts and unfurled leaves of developing leaf buds. They are laid in pits, each egg being attached by a minute hook. The egg period has not been ascertained, but is probably from five to eight days. The nymphs are pink in colour and flattened. They produce a waxy secretion from the abdomen in the form of threads. This secretion is produced in quantity usually entirely covering the nymph. Attacked foliage is covered with this secretion. Wing-lobes appear in the third instar and succeeding instars. The nymphal period appears to be variable, but an insufficient number of records was taken. The minimum period observed was eight days and the maximum 15 days.

Alternative food-plants have not been ascertained, but nymphs have been observed on a number of undetermined bush plants. *Cola acuminata* is also attacked, and appears to be a more preferable food-plant than cacao.

Natural enemies consist of the larvæ of the Syrphid flies, *Baccha picta Wd. var. Superpicta* Bezzi., *B. præusta* Bezzi and *B. sinuata* Brun. (Plate XV, fig. 2). The larvæ of these Syrphids are common in *Psylla* colonies.

As attack results from the same conditions favourable to *Aphis* attack control measures that apply for *Aphis* apply here.

SCALE INSECTS.

Although scale insects are considered serious pests of cacao in other cacao producing countries, they are of comparatively no importance here at present.

The following scale insects have so far been recorded in this country : —

Stictococcus sjostedtii. Ckll. attacking succulent shoots and pod peduncles. Attended by the Red Tree Ant, *Oecophylla smaragdina.*

Stictococcus multispinosus. Newst. attacking pod peduncles. Attended by black ants.

Ferisia virgatus. Cokll. Mealy bug attacking pod peduncles and attended by black ants.

Aspidiotus ? cyanophylla. Sign on cacao foliage. A number of other species have been observed on stems, leaves and pod peduncles, but have not yet been determined.

LEAF EATING INSECTS.

Earias biplaga. Wlk. (Plate XIV, figs. 1 and 2).

Earias biplaga is a small Tinæid moth measuring approximately a little over 1 mm. in length and 2 mm. from wing-tip to wing-tip. When at rest the wings are carried folded over the body. The adult is nocturnal.

The female is green in colour with a large brown blotch on each fore wing. In the male this mark is absent.

Eggs are laid singly at night on the bracts of leaf buds. The larvæ commence to feed inside the leaf bud and eventually complete their life on the succulent foliage and also the bark. The full grown larva is green-brown in colour and spiney. Pupation takes place on the stems in a tough fibrous boat-shaped cocoon. The larval stage varies from 18 to 21 days, and the pupal period eight to nine days.

Attack is confined to new flushes of foliage, and is common on young cacao which is improperly shaded and growing under bad soil conditions. Attack may result in complete defoliation of the newer foliage of young trees. It commonly follows *Sahlbergella* damage attacking the new foliage put out from the lower part of the stem after the upper foliage has been destroyed.

Natural controls consist of two undetermined Hymenopterous parasites, one of which, a Braconid, illustrated in Plate XIV, fig. 7, which is highly hyper-parasitised. No other controls have been observed.

Alternative food plants are few in the cacao belt. *E. biplaga* is the most serious boll worm of cotton in British Togoland. In open country it has been bred from Okro, other *Hibiscus* spp., and *Urena lobata.*

As attack on cacao is always associated with lack of shade and poor soil, conditions control obviously can only be brought by remedying these conditions.

When secondary to *Sahlbergella* attack control consist of first controlling the primary cause.

Stomach poisons such as lead or calcium arsenate can be used with success where practicable.

OTHER LEAF EATING PESTS.

A weevil at present undetermined and of unknown genus, attacks the back of herbaceous shoots of young cacao under similar conditions that are favourable to *Earias biplaga* attack. Occasionally damage is serious.

The Rutellid beetle, *Adoretus hirtellus*, has been reported as eating foliage of older trees at Aburi some years ago. Attack has not been observed recently.

The Curculionid beetle, *Apoderes flavoebenus*, does no economic damage to cacao. It is only mentioned here from a point of interest. The adult selects a young cacao leaf and makes a series of transverse cuts in the mid-rib from the apex of the leaf to about half-way towards the base, thus destroying its rigidity. The leaf is then rolled up, the beetle using its legs and jaws. Just after commencing to roll, an egg is laid on the tip of the leaf, so that it will be enclosed in the roll. The ends of the cylinder are folded in so that an enclosed cylinder is formed and the leaf rolled up to about half its length. Owing to the cutting of the mid-rib the leaf remains rolled up after the beetle has left. The egg hatches and the legless larva feeds on the walls of the cylinder, eventually pupating inside. The adult emerges by biting its way out.

Other leaf-eating insects are the larvæ of the Arctiid moths, *Diacrisia mundata* and *D. rattrayi* (Plate XIV, fig. 5), which are omniverous and occasionally attack moribund young cacao. There is also an undetermined cacao leaf roller which is of minor importance economically.

Other leaf-eating caterpillars have been observed, which, on occasion, have done serious damage. These attacks have, however, been purely sporadic in occurrence, the only danger being that at some time they may become important pests.

INSECTS ATTACKING PODS.

Moth Borer of Cacao Pods. Characoma stictograpta. Harp.

Little is known of the life-history of this Noctuid moth. Eggs are laid on the surface of the pod at the point of contact of two pods or a pod with the main trunk, the young larva hatching out and boring into the pericarp of the pod, piling up heaps of grass and silk outside the tunnels. Only the pericarp is attacked, and the seeds develop normally unless fungus disease follows. Attack is more prevalent in areas of heavy shade and humidity, *i.e.*, those areas where fungus diseases predominate. Undoubtedly damage by the larvæ of this moth results, in a number of cases, in subsequent fungus infection.

Pupation takes place on the surface of the pod or in the ground. One Hymenopterous parasite of the larva has been found, but has not yet been determined.

A black ant, probably *Crematogaster* sp., has been observed to eat the epidermis of nearly mature pods at Aburi. The epidermis is carried away to the arboreal nests of the ants and probably utilised in the fungus gardens.

INSECTS ATTACKING STEMS.

Tragocephala gorilla, Thomp., bores in branches of mature cacao up to three inches in diameter, but is uncommon as a serious pest.

Tragocephala chloris, chev. (Plate XVI, fig. 4) and *T. gorilla* bore in young cacao usually growing under unsuitable conditions. The stem is girdled just below the main growing shoot and an egg inserted just below. This prevents further growth and possible distortion of the egg. The young larva bores down the stem, making frequent holes to the exterior to get rid of its frass. The larval life lasts from four to five months. When ready to pupate the larva turns round in its bore and plugs the upper end with frass.

The Cerambycid beetles, *Glenea* spp. (Plate XVI, fig. 3) bore in the base of old cacao trees just under the bark and occasionally cause complete girdling of the tree. Attacks by these beetles are localised and are uncommon.

The larva of the Cerambycid, *Mallodon downesii*, Hope (Plate XVI, fig. 2), bores in the main stems of older cacao, particularly in cacao growing in areas that have been deforested since cacao were established. The tunnels are extremely large and have no connection with the outside. Trees are completely or partially destroyed. Owing to there being, as a rule, no frass holes to the outside, the beetles cannot be located, and excission causes more damage than the ravages of the larvæ. *Mallodon downesii* has also been recorded as attacking rubber in heavily deforested districts. Normally, *Mallodon* is a forest tree borer, and it is possible that in areas in which recent heavy deforestation has occurred the beetle has adapted itself to cacao and rubber in the absence of its usual food.

The moth borer, *Eulophonotus myrmeleon*, Feld. (Plate XVI, fig 7), has been recorded as attacking cacao, but is uncommon. The larvæ bore in the stems of mature trees and when ready to pupate eat out a perpendicular slit in the bark. Pupation takes place inside the slit, the full-grown moth emerging through the opening.

Occasionally shot-hole borers also attack the main stems of cacao. *Xyleborus nitidipennis*. Murray, and *X. urichi*. Samps. have been recorded as attacking cacao in this way.

The larvæ of the Cerambycid beetle, *Armatosternum buquestiana* Wh., has also been recorded as boring in cacao.

INSECTS ATTACKING ROOTS.

An undetermined species of Termite has been observed to attack the roots of young cacao in Togoland and the Trans-Volta District of the Colony. The root system is entirely destroyed. This is the first record of Termites attacking healthy cacao. Control consists of destruction of nest and queens in the vicinity.

PLATE XVI.

Fig. 1

Fig. 2

Fig. 3.

Fig. 4

Fig. 5

Fig. 7.

Fig. 6.

MINOR PESTS OF CACAO.

Fig. 1.—Cacao Pod Borer. (Characoma stictographa. Harp.)

Fig. 2.—Mallodon downesii. Hope.

Fig. 3.—Glenea fasciata. F.

Fig. 4.—Tragocephala. Chloris. Chev.

Fig. 5.—(*a*) Egg of Tragocephala sp. in situ.
(*b*) Girdled stem above egg.

Fig. 6.—Stem cut away to show pupa of Tragocephala sp.

Fig. 7.—Eulophonotus myrmeleon. Feld. (Female)

PAPER No. XVIII.

ATUABO COCONUT PLANTATION.

By C. H. KNOWLES.

The Atuabo coconut plantation is one of the plantations, established in the Western, Central and Eastern Provinces, to demonstrate to the people the use and value of the coconut palm for commercial purposes and especially on land near the coast which is generally regarded as of little use for permanent crops.

The plantations are established on communal land, leased for the purpose at a nominal rent. When Government has recouped the expenditure involved, the plantations will be handed back to the people.

The idea of using public money for the benefit of owners of land is perhaps an unusual one, but the establishment of new industries is considered of such great importance that, so long as there is a reasonable prospect of the amount expended being regained, the use of public funds in this manner is justified.

The Site.

The town of Atuabo (population 738 in 1921) lies about halfway between the ports of Axim and Half Assinie—the latter being at the extreme west of the coast line of the Colony. The Atuabo plantation holds a central position in a considerable belt of similar land and may be taken as quite typical of the belt. The plantation are on the town boundaries of Atuabo and extends to the village of Anochi. It forms a narrow, and approximately rectangular, block some seven times as long (along the coast) as it is wide (inland). Since operations were intended on a plantation scale, the area aimed at was 340 acres. This, however, could not be realised, but by small additions to the original block a total of 295 acres has been obtained.

Commencement.

Work commenced in the middle of 1920 with clearing lines 30 feet apart, some 6 feet wide, and selecting and clearing a site for a nursery of seednuts. The land was covered with a fairly heavy growth of Phœnix and Borassus palms between which were growing small trees and scrub. The vegetation formed a fairly dense covering, particularly on the inland boundary, which borders on swampy land which in the wet season practically forms part of the lagoons which run parallel to the coast.

Seednuts.

Seednuts were obtained from Lome (Togoland—now French territory, but in 1920 under occupation by a combined Anglo-French force). Several excellent plantations exist in Togoland, coconut planting having been encouraged by the Germans.

Owing to transport difficulties, many losses occurred in the seednuts, mostly through germination before the nuts arrived. Between August and December, 1920, some 20,000 seednuts were received at the plantation and set out in nurseries. Various additions were made to the nurseries from time to time until approximately 30,000 had passed through the nurseries. A fire in March, 1921, destroyed 3,000 seedlings in the nurseries, while cattle, grasshoppers, and Rhinoceros beetles are reported as having done damage to the seedlings in addition to a number scorched by the sun as well as those lost in transit referred to above.

Clearing the Lines.

The original clearing was arranged to deal with 6 feet strips. 30 feet apart, with crosslines 25 feet apart, in the centre of the intersections of which the nuts would be planted.

Lining-off was not as easy in a heavy growth of bush as it would have been on a cleared land, hence an undue expenditure on this work, both for the original lining and in subsequently correcting errors.

Transplanting.

Preparations were made for transplanting to commence in the wet season in 1921, and by September of that year some 240 acres had been cleared (in lines) and 156 acres were planted, with some 9,088 plants. The method of planting adopted was the usual one of setting the seedlings at the bottom of deep open holes and allowing the soil to wash in gradually.

Clean Weeding.

The lines originally cleared had become overgrown the latter part of 1921, and necessitated much additional attention. It was seen that the land would have to be completely cleared, and clean weeding practised. The bush in between the rows of coconuts was therefore attacked, and by the end of the year it had practically been completed. It is certain that both the original clearing in lines and the subsequent clearing of the bush in between was more costly than would have been the original clearing of the whole area. As soon as the condition of the land permitted, the people were encouraged to plant groundnuts, shallots, cassava, gourds and certain other crops in between the coconuts. As the palms spread, this inter-cropping was curtailed, and it disappeared in 1926 in the bearing areas. It is not considered that the palms were harmed in any way by this catch-cropping—on the other hand it is suggested that the cultivation of the land has been beneficial.

In April, 1924, a count of the palms showed that 12,675 were established (218·5 acres); 1,315 failed (22·7 acres ; 49 blanks (0·9 acre). The last-named were places which had evidently been overlooked in transplanting. The vacancies in due course were all supplied, and in 1923 the area planted reached a total of 295 acres, the present area.

Climatic Conditions.

The area in which the plantation is situated is the wettest in the Gold Coast, the annual rainfall being about 60-70 inches on an average of 110-120 wet days a year. The coconut palm is very accommodating in the matter of rainfall and can adapt itself to a variety of widely differing climatic conditions. The copra industry is established in some parts of the Philippine group with 240 inches of rain a year, and in Keta (Gold Coast) and some South Pacific Islands the palms bear satisfactorily under about 20 inches a year.

The advantage of the heavier and more regular rainfall is very pronounced in the early stages of the history of a coconut plantation. There is less trouble in establishing and maintaining a nursery, while after transplanting, losses are reduced to very few instead of the formidable percentage lost in dry places. It is easier to maintain uniformity in the development of the coconuts in wet places—thus reducing the cost of establishing and tending to hasten the returns.

The Young Palms.

The young palms developed in a normal manner. Forty were recorded as flowering at the end of 1924, since which date flowering and fruiting have increased regularly and rapidly.

Pests, etc.

A complete list of known pests of coconuts in the Gold Coast has not yet been compiled, but attention is being given to the matter. There is no evidence of any pest so serious as to endanger the success of coconut planting. Rhinoceros beetles and grasshoppers did some damage in the nurseries and in early stages of the plantation. A number of seedlings were scorched by the sun when in the nurseries, while cattle were exceedingly troublesome at one time. Scale has regularly been present and some leaf-eating caterpillars, but both the scale insects and the leaf-eaters are kept in check by natural enemies.

Use of Early Maturing Plants.

Fruiting was fairly common among the older palms in 1926, and seed was selected from the fruit so obtained for planting purposes.

Some objection has been raised to the use of such early seed for planting purposes, hence it seems desirable to offer some remarks on the question.

The average age for coconut palms to begin to bear is seven to eight years. Instances are known of palms under plantation conditions bearing when only four years old, while other palms at 20 years have never had fruit. The difference in financial results of two plantations, one of which had most of its palms bearing at four years, while the other at 20 years had not commenced to give revenue, needs no emphasizing. It is not likely, of course, that the majority of palms on a plantation would be either extremely early or extremely late bearers, but since the establishment of a coconut plantation is a costly undertaking, every effort should naturally be directed towards taking whatever steps are possible to hasten the arrival of the first crop.

Early or late fruiting appears to be a quality capable of being transmitted through the progeny of a plant. It therefore would seem to be a quality which can be improved by careful selection of early bearers. With permanent crops, the plants to give the earliest crops are very important, provided they are sound and robust plants of a satisfactory type, and provided further the crop is satisfactory as regards both quality and quantity. There is no evidence that early-bearing coconut palms cease to bear at an early age, or are otherwise unsatisfactory for plantation purposes. A sound mature seed of proper development and having the desired characteristics, but produced by a very young parent plant, shows no physiological differences whatever to one from a much older plant.

The general advantages in using the first crops for seed are the resulting saving in time and the absolute certainty of selecting from early bearing plants.

The Crop.

The plants at Atuabo were bearing good crops in October, 1927. The bunches were large, and the nuts of fair size. Young coconut palms frequently lose what seems to be a large number of nuts which fall off the branches at an early stage. This was in evidence at Atuabo. It is of no particular importance, as the young bunches are made up of many more nuts than the palm could mature. As planting commenced at the end of the plantation near Atuabo, and gradually proceeded towards the Eastern boundary, fruiting is principally in the Western block. It will not be possible to offer figures pretending to show the yield per acre until bearing is more general. The nuts are allowed to fall from the palms. This ensures that the nuts are ripe, and the husks are in good condition for fuel.

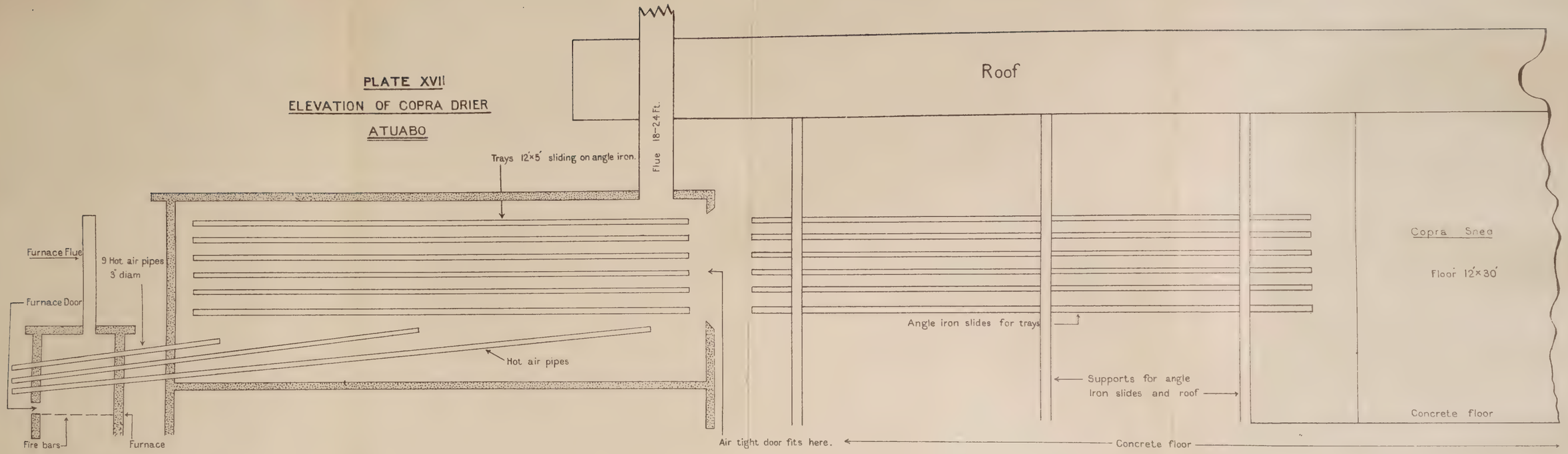
Treatment of the Crop.

Sun drying is carried on in many places where the rainfall is heavier than at Atuabo. But since the plantation is serving as a demonstration plantation, it was decided to instal some form of artificial dryer as the main means of working up the crop, depending on sun-drying to supplement artificial drying when possible and

PLATE XVII

ELEVATION OF COPRA DRIER

ATUABO



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desirable. There are several forms of proprietary artificial drying-machines on the market for various crops and including some for copra. A collection of such machines would doubtless be instructive to enable the proper comparisons to be made, but such a procedure is, of course, out of the question on a small plantation.

Since, however, the principles of drying by hot air are well known, the building of a drying apparatus presents no particular difficulty, and if constructed of material obtainable locally, has the additional advantage of cheapness and certainty of construction within a specified time. Dryers built of wood and concrete with a few iron parts, generally obtainable in a country of this kind, were designed by the writer several years ago and have been constructed and usefully operated. The small dryer at Atuabo is of this design. A diagram is attached. (Plate XVII.)

Briefly, it is a chamber of concrete, having a series of perforated trays which can be run in and out of the chamber on slides of angle iron. An air-tight door is provided. A series of iron pipes passing through a furnace enables a supply of hot air to be delivered into the chamber at the bottom, while at the top at one end a wooden flue of suitable area and length creates a " draught " and provides for the circulation of hot air over the kernel of the coconuts spread on the trays. The hot air removes the moisture and converts the kernel into copra.

The dryer at Atuabo has a chamber 12 feet by 5 feet by 4 feet, accommodating five trays, which hold a charge of about 1,200 to 1,500 lbs. of kernel, giving about 700-900 lbs. of copra. By working continuously the kernel can be completely dried in 24 hours, but, unless there is a pressing need, it is better to leave the charge in for 48 hours, banking the fire at night.

The husk from the coconuts, the kernel of which forms a charge, are sufficient to heat the air for drying that charge. The tendency is to get too great a fire, which would heat the air to such an extent as to char the kernel.

The dryer was built at a cost of under £200, including the comparatively heavy freight along the beach from Axim. Considerable trouble was experienced in regard to the supplies of iron pipe and angle iron—materials in common use in most countries and which undoubtedly would be stocked here when demand arises. There are certain points which must be carefully attended to—the first is that the building, door and flue must be *air-tight*. The best form of flue is a square one made of the proper length of boards 12 ins. wide, giving a cross section of 11 ins. square, with no joints except at the corners. The boards should be smooth to provide a good fit, and tar, thick paint, putty or other material should be painted on to the wood before forming the joints. Sound boards are essential. A large dryer should have two, three or more flues, all 11 ins. square and built in an air-tight manner—rather than one of larger cross section, which is never likely to be air-tight.

The iron tubes which provide the hot air supply pass through a furnace separated from the drying chamber to avoid risk of fire, they communicate with the outside air at one end and the chamber at the other. The tubes should be in series of three, six, nine, or other number divisible by three, and they should project into the drying chamber so that one-third of them communicate hot air near one end, one-third about the middle and the other third take the hot air to the far end. The hot air is thus more evenly distributed. If inspection shows that the drying is proceeding unevenly, correction can be made by blocking the outer end of the proper air tubes. Baffle plates of perforated iron or other metal can be put over the inner ends of the air tubes to aid further the more even distribution of the hot air. Thermometers are a necessity for the proper regulation of temperature. The distance-reading thermometers enable the indicating dials to be brought to a convenient spot, one recording the temperature of air on entering the chamber and another the temperature of air at the foot of the flue. As drying proceeds, the difference between these will decrease. Air should enter the chamber about F. 160° (82° C.). When the kernel is quite fresh a few degrees higher would do little harm, but it is better to avoid all risk of over-heating by maintaining a regular temperature as suggested. A sketch plan of the dryer is shown in Plate XVIII.

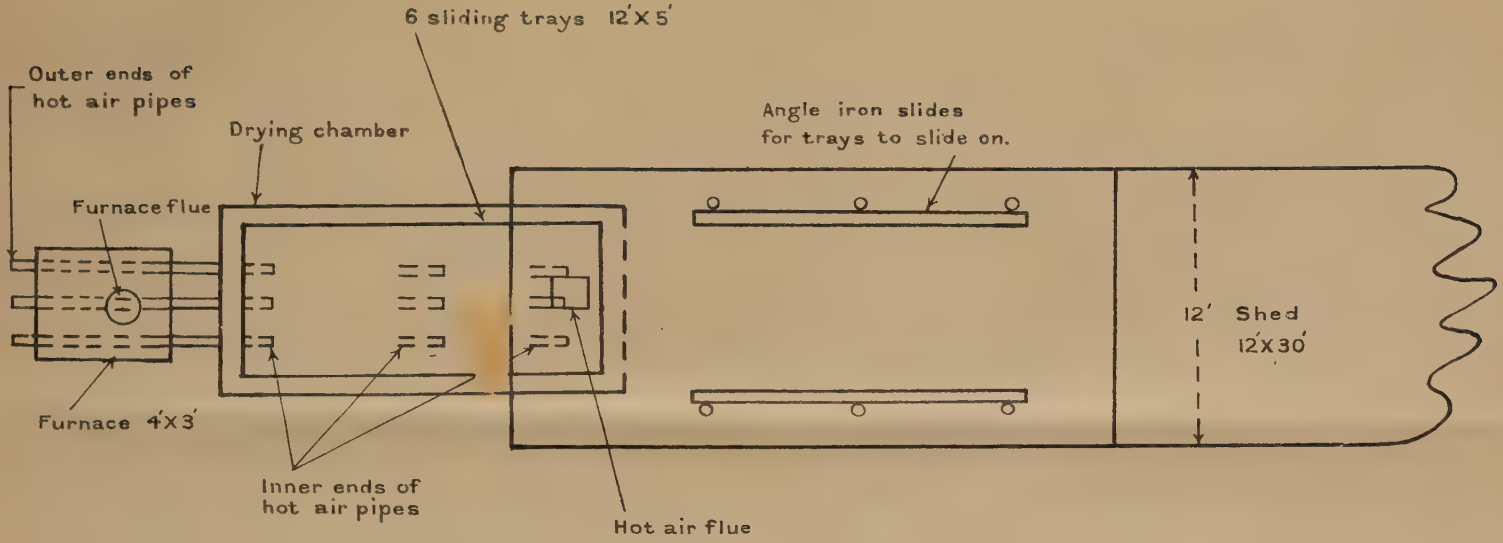
The following list shows the crop dealt with since the dryer was erected:—

	No. of Nuts dealt with.	Wt. of Green Copra.	Copra.	No. of Nuts per Ton of Copra.
		Lbs.	Lbs.	
October	2,442	—	708	7,726
	17,752	10,000	6,057	6,565
November ..	25,000	15,587	8,876	6,308
December ..	23,419	12,616	8,303	6,317
Total ..	68,613	—	23,944	6,377 average.

The large number of nuts per ton seems to indicate that they are very small, a fair average being well below 6,000. As a matter of fact, the nuts had been collected some months before the dryer was ready for use or before other satisfactory arrangements could be made for working them up into copra. They were placed in heaps and many of them germinated. When splitting for drying, those in which germination had not proceeded very far were used, but since some of the kernel had been used up in the processes of germination, the yield of copra was reduced, hence the number of nuts required to make a ton was increased.

The percentage of copra to kernel, 58·4, is satisfactory, so far as can be seen without analyses of the kernel and copra, which are not yet complete.

PLAN OF COPRA DRIER, ATUABO.


6 sliding trays 12'X5'
Outer ends of hot air pipes
Drying chamber
Angle iron slides for trays to slide on.
Furnace flue
12' Shed 12'X30'
Furnace 4'X3'
Inner ends of hot air pipes
Hot air flue

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The following is the complete list of the crop, showing the use made of the nuts:—

Nuts Collected.		Disposal.	
To March, 1926 ..	81	For Copra	45,194
April, 1926—March, 1927	29,737	For Seed	2,076
April, 1927—Oct., 1927 ..	109,078	Exhibits	187
		Distributed ..	7,858
		Useless	3,369
		On hand	80,212
	138,896		138,896

The Cost of the Plantation.

Expenditure on establishing a plantation can conveniently be regarded as ended when crop begins to arrive in appreciable quantities. From the list above it will be seen that considerable quantities of nuts were gathered from April, 1927-28, so it is proposed to take expenditure up to the end of March, 1927, as for the establishment, and from April, 1927, as working expenses.

In order to encourage the planting of coconuts, the Government did not confine its interest to the establishment of the plantation. The overseer employed for the first six years was a specially qualified officer from Ceylon, who, in addition to the supervision of the plantation, carried out itinerant duties in the neighbourhood. It would therefore be unfair to charge against the establishment of the plantation the whole of this officer's salary.

The cost of establishing the plantation is, allowing for the above, as below:—

Per acre for 295 acres.

	£	s.	d.
Seed	1	4	1
Tools		2	5
Labour (*)	11	11	10
Rent		4	10
Supervision	6	0	0
	£19	3	2

(*) Labour item includes erection of temporary quarters for overseer and labourers, nothing being shown under buildings. The cost of seed is high for the reasons given previously. It has been indicated earlier where savings should have been possible in the labour bill.

Faults in Copra.

The chief faults of copra in this country are immaturity of the nuts, and mould on the finished product. The first fault is

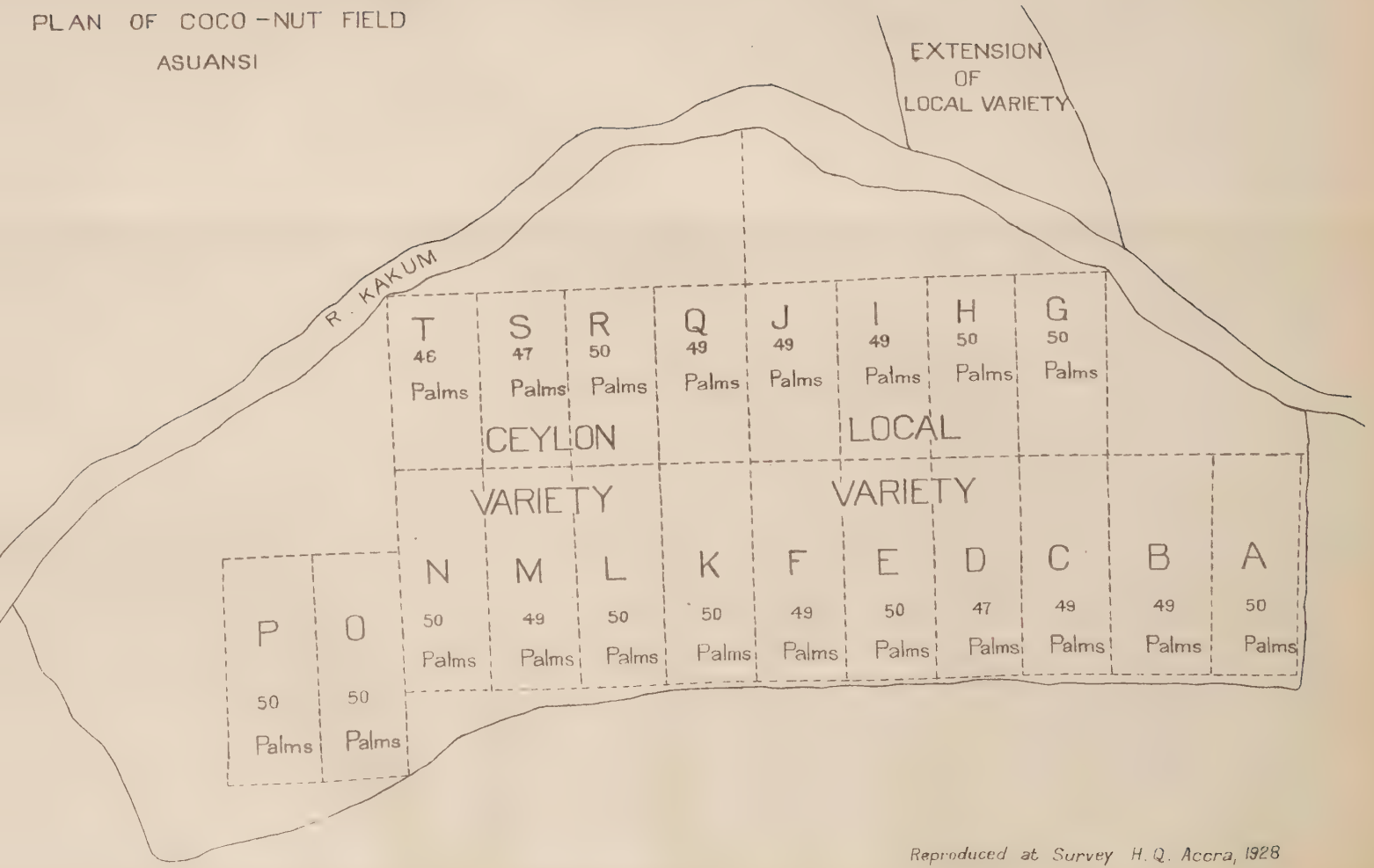
due entirely to the method of picking the bunches from the palm. The method recommended is to allow the nuts to fall naturally, which they will do when they are mature and the husk is nearly dry. The kernel is then as fully developed as it will be, and in the best condition for turning into copra, and the husk is suitable for use as fuel.

The presence of mould is an indication of insufficient drying. All products which are made into a marketable condition by removing surplus water are liable to be attacked by moulds of various kinds unless the drying is carried far enough. A little experience is sufficient to enable one to judge by the appearance of the material when split across so as to expose a fresh internal surface, whether the drying has been carried far enough, which is the case when the freshly exposed surfaces of the kernel, on being split across, show a uniform pearly appearance with no white bands, which, during the earlier stages of drying, show as belts parallel to the inner surface of the kernel and of gradually decreasing width.

PLATE XIX

PLAN OF COCO-NUT FIELD

ASUANSI



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PAPER No. XIX.

VARIATIONS IN YIELDS OF COCONUTS AT ASUANSI.

(*The field work dealt with in this paper has been conducted by* A. B. CULHAM *and* J. STEELE, *and the data collected by* S. R. B. FLETCHER. *The paper has been prepared by* N. P. CHAMNEY.—*Editor.*)

History of the Trial.

The local variety of coconuts used in one section of this trial was planted in 1910 and the Ceylon variety in 1912. In each case the planting distance was 25 feet by 25 feet.

In the case of the local variety, 30 planting lines were made with varying numbers of trees according to the configuration of the ground, and also the fact that a river bounded the back of the area. A total area of 10·5 acres was covered and 713 palms planted. Of these, 673 have survived and 100 of these are not fruiting.

The area covered by the Ceylon variety is 12·3 acres, with 41 planting lines, of varying content for the same reasons as in the case of the local variety.

The area varies considerably, being dry on rising ground, with rock outcrops on plots C, D, E, F of the local variety hereinafter mentioned, and falling to swampy low lying ground in plots O and P of the Ceylon variety. This probably accounts for the large average deviations on the plots employed, which were, however, the most convenient divisions which could be employed.

Plate XIX shows the arrangement of the field and the method of dividing it to get the ten most equal plots for each variety.

In each variety the plots were arranged so as to get as near 50 trees as possible in each plot, and at the same time to avoid the outlying areas where, owing to environment, vacancies and non-fruiting trees were frequent. It is obviously impossible to reproduce the actual spot plans made marking the position of each tree as the result would be too unwieldy, but the plans and notes thereon show that the empirical plots employed are in the best areas available.

From 1919 the individual records of the trees were kept, and this has been continued to date. The tabulated records involve 12,288 separate observations, and have had to be analysed in order to bring them within the space available for reproduction.

Actual possibilities of selection of high yielding strains and other methods of improving yields which were the original purpose of the trial are outside the scope of this paper, and are therefore left to a future date for consideration.

The Field as a Whole.

The annual yields of the two varieties from the field and per acre are given in Table I. It will be seen the average yield per acre over the whole period 1918-26 is very little different for each variety, and the slightly higher figure for the local variety can be explained by the fact that these palms were planted two years before the others and are nearer, therefore, to full bearing.

The figures compare not unfavourably with those obtained in the East, where the yield varies from 5—40 nuts per productive tree on the average for coastal plantations where the coconut is in its natural habitat. The yield at Asuansi approaches the lower end of this scale in that the average yield is 13—14 nuts, but this figure includes both productive and non-productive trees, and also Asuansi is an inland station some 13 miles from the coast, and must therefore be considered to present artificial conditions.

Rainfall figures to fix the limits within which coconuts can be successfully grown are not available, but the rainfall average for Asuansi, 50·96 in. (Bulletin No. 2 of the Department), appears to be sufficient to maintain good growth and cropping power, even on the parts of the field where the soil is rocky and poor.

The average number of wet days to the end of 1926 is 122, showing an average distribution of rain over the year, a more important point for coconuts than the total deposition.

Coconuts will grow on the coastal belt with much less rainfall, and it may be assumed, therefore, that there is no adverse influence on the yields at Asuansi in this respect.

TABLE I.

YIELDS OF THE WHOLE FIELD.

Year.	Local Variety. Total Nuts.	Local Variety. Nuts per Acre.	Ceylon Variety. Total Nuts.	Ceylon Variety. Nuts per Acre.
1919	4,657	443	9,257	753
1920	4,127	323	12,789	1,040
1921	6,013	573	13,288	1,080
1922	7,444	709	11,223	912
1923	10,260	977	11,654	948
1924	10,962	1,044	4,640	377
1925	15,060	1,434	5,448	443
1926	19,525	1,859	21,416	1,741
Mean ..	—	920	—	912

The distribution of yield over the year is given as percentage in Table II. No striking cropping season is evident, but the local variety yields on the average heavier crops during March, April and May, while the Ceylon variety bears more heavily during the period August-November.

The differences are, however, very slight, and are not comparable to the definite cropping seasons associated with other crops.

TABLE II.

MONTHLY DISTRIBUTION PER CENT. CEYLON VARIETY.

Month.	1919	1920	1921	1922	1923	1924	1925	1926	Mean.
									%
January ..	·9	—	6·6	11·2	8·3	11·2	4·3	3·6	5·8
February ..	·4	6·8	5·9	10·9	8·8	21·0	6·9	2·7	7·9
March	11·8	5·8	17·5	7·5	11·7	10·2	6·9	4·1	9·4
April	13·0	—	6·0	8·9	10·8	4·2	5·9	5·8	6·8
May	8·9	6·5	10·7	4·2	11·2	6·4	5·2	8·2	7·7
June	7·4	8·9	3·5	6·4	6·4	9·0	4·6	4·7	6·4
July	10·8	17·9	4·1	8·9	7·8	7·3	7·7	4·4	8·6
August	13·2	12·1	4·3	9·1	6·2	9·2	9·7	8·2	9·0
September ..	9·9	13·1	9·0	8·0	8·6	4·2	11·8	15·6	10·0
October ..	10·3	10·7	13·3	7·7	6·9	4·9	12·6	14·0	10·0
November ..	9·3	12·0	11·3	7·6	6·9	5·8	10·2	12·7	9·5
December ..	4·1	6·2	7·8	9·6	6·4	6·6	14·2	16·0	8·9

LOCAL VARIETY.

Month.	1919	1920	1921	1922	1923	1924	1925	1926	Mean.
									%
January ..	1·7	—	4·9	6·5	4·9	8·1	3·3	5·6	4·4
February ..	·7	5·9	7·4	6·1	6·3	7·8	5·6	5·4	5·5
March	29·6	8·6	14·5	7·0	8·6	9·7	7·1	7·4	11·6
April	16·2	—	15·7	12·9	10·9	9·7	8·6	8·2	10·3
May	10·3	17·9	10·0	6·7	10·8	14·1	8·0	12·3	11·3
June	7·9	12·3	5·1	10·6	8·6	13·5	7·7	5·9	8·9
July	7·9	12·9	7·2	9·1	10·0	9·0	10·7	9·1	9·5
August	7·9	9·9	6·8	11·1	7·3	7·1	10·5	7·7	8·5
September ..	3·1	6·8	7·7	6·9	8·0	5·8	10·9	12·4	7·7
October	6·3	8·9	4·8	7·6	8·6	4·8	9·6	10·7	7·8
November ..	3·9	10·7	6·9	7·6	7·9	5·1	8·5	8·2	7·3
December ..	4·5	6·1	9·0	7·9	8·1	5·3	9·5	7·1	7·2

Degree of Uniformity of the Field.

In order to test the field for uniformity with the idea of using it for further experimental work, ten plots have been taken out of the area allotted to each variety. These plots are equal in size and exactly similar in shape, and contain five rows of 10 trees each, each plot being therefore twice as long as it is broad.

They run from east to west in each case and are as similarly placed in each variety as it is possible to get them, owing to the difference in shape of the areas treated. A diagrammatic plan of these plots appears in Plate XVIII, with notes on the number of vacancies and non-fruiting palms in each. They are designated by letters beginning with the native variety.

Table III gives an analysis of the 20 plots in order that they may be compared with each other, and also their seasonal variation determined.

Looking first at the seasonal variation, it will be seen that this is very large in both varieties, but more so in the local than in the Ceylon variety.

This is probably due to the fact that the trees are yet comparatively young, and therefore the variation is much larger than will probably be the case when the trees are in full bearing. The deviation is steadily growing less and may be expected to level up considerably during the next few years.

It is, however, too great at present to allow of entirely reliable experimental work being carried on as yet.

The variation between plots is even more marked, and in order to understand this, it is necessary to state that there are distinct areas of swampy ground and rocky thin soil in each area.

TABLE III.

ANALYSIS OF THE 20 PLOTS.

Yields of Nuts per Plot.

Plot Nos.	1919	1920	1921	1922	1923	1924	1925	1926	Mean of 8 years.	Aver. Deviation as % Mean.
					LOCAL VARIETY.					
A ..	839	707	954	1,472	1,819	2,002	2,501	2,512	1,601	37·9
B ..	1,260	803	1,352	1,784	1,692	1,649	2,226	2,595	1,670	25·2
C ..	695	642	731	824	1,280	1,266	2,172	2,039	1,206	42·1
D ..	108	193	226	207	531	483	833	1,050	453	59·7
E ..	55	121	229	115	414	331	773	1,256	412	73·3
F ..	28	91	172	189	372	382	547	1,155	367	66·9
G	631	453	703	797	1,041	1,174	1,657	2,095	1,069	40·0
H ..	79	174	346	143	418	502	863	1,306	479	64·8
I ..	14	96	157	128	454	437	731	1,066	385	74·8
J ..	20	11	109	117	369	288	423	1,049	298	79·3
Mean ..	373	329	498	578	839	851	1,273	1,612	—	—
Average Deviation % Mean ..	98·3	78·3	70·2	81·4	59·4	63·1	54·4	34·0	—	—

CEYLON VARIETY.

Plot Nos.	1919	1920	1921	1922	1923	1924	1925	1926	Mean of 8 years.	Aver. Deviations % Mean.
K ..	705	1,114	944	724	942	366	301	1,544	885	35·8
L	1,553	1,411	1,315	1,130	1,153	414	346	1,492	1,101	32·8
M ..	1,582	1,560	1,489	1,115	1,294	403	505	1,982	1,241	34·2
N ..	720	1,330	1,263	926	1,027	243	331	1,774	953	41·9
O ..	994	988	1,008	832	700	228	406	1,939	889	38·5
P ..	437	718	993	1,013	804	204	307	1,691	758	46·5
Q ..	41	135	434	262	429	394	195	1,109	499	53·4
R ..	273	552	537	366	448	178	195	836	423	40·2
S ..	617	915	900	534	508	129	191	1,092	498	56·5
T ..	428	937	975	706	776	194	226	1,167	676	43·7
Mean ..	735	966	986	759	808	275	300	1,463	—	—
Average Deviation % Mean ..	52·3	32·2	22·1	34·4	33·2	36·4	26·3	21·8	—	—

These areas fall, roughly, as under:—

Rocky ground, Plots D, E, F, P.

Swampy ground, Plots A, A, M, N, O, R.

On referring to Table III it will be seen that the former have a much higher average deviation than the latter, probably due to the fact that they suffer from lack of soil moisture in dry years, which is an important factor in the growth of coconuts.

In order to conduct satisfactory experimental work on this area, it will be necessary to continue the recording for a year or two more, so as to be able to dispense with the yields of the earlier years while the palms were becoming thoroughly established. After 1921 much greater uniformity can be seen, and another two seasons' yield, 1927-28, will probably bring the variations within reasonable limits.

Comparison of the Two Varieties.

It is difficult to make accurate comparison between the Ceylon and local varieties in that the former was not established till two years after the latter.

A glance at Table I will show that the mean yield over the eight years recorded only differs by eight nuts per acre, and therefore in cropping powers we may expect that there will be little difference between the two. Such points as the weight of nuts and the amount of copra to be derived from an equal weight of nuts of each variety are outside the matter of this paper.

A point that calls for comment is shown in Table III. The greater variation displayed by the local variety, as compared to

the Ceylon may be judged, in the light of the small difference in yield per acre (see Table I), to be due to differences in soil and environment rather than to any inherent difference in the cropping power of the varieties.

On inspection of the palms *in situ*, it is difficult to see as much difference between the varieties or between the plots, and this emphasizes the necessity for careful recording of yields over a period of years and elimination, as far as possible, of likely errors by use of the figures, before experimental plots can be laid out to test really thoroughly any problem which requires elucidation.

PAPER No. XX.

THE DISTRIBUTION OF WHITE AND PINK SEEDS IN THE COLA PLANT.

By N. P. CHAMNEY.

The Cola tree (*C. acuminata*) bears nuts, which as they contain 2 per cent, of caffeine and 2 per cent. of theobromine, are of considerable value as a stimulant and are used as a masticatory by the natives of the West Coast.

Two types of nuts exist which differ in colour and in flavour, the white being preferred to the pink. The former is consequently of much greater market value and commands four times the price of the latter.

As a result of this difference in price the Department of Agriculture determined, in 1910, to attempt to produce strains of Cola which produced only white nuts. It was found that while the majority of the existing trees produced pink nuts some produced white, and some both white and pink. White seed was obtained from various sources of trees bearing white nuts, and these were planted at the agricultural stations with the idea of keeping records of the individual trees and obtaining a supply of seed for future planting.

When these trees matured and bore fruit, very few gave white nuts entirely and some pink only.

No attempts at pollination of white by white were made, but seed from those trees bearing a large proportion of white were used for future planting. The original trials were made at the Aburi Botanic Gardens and Kibi Experimental Station and later extended to Asuansi, Hemang, Peki and Wiawso, but these later planted plots are not advanced sufficiently to deal with.

Records of eight years' yields are available from Aburi and Kibi, and from these it appears probable that the largest proportion of white nuts are produced by trees in full bearing, and that the ratio of white to pink increases up to that point. Later on the proportion falls again to the original ratio or nearly so.

The fact that the ratio increases is mentioned by H. F. MacMillan in his book " Tropical Gardening and Planting," page 382, and is fully borne out by the results at the above stations.

The Trials at Kibi.

The field at Kibi is composed of 9 lines of 21 trees, planted 30 feet by 30 feet, but only 168 actually were established. For the purpose of this paper, 24 of these are eliminated for the following reasons:—

(*a*) 11 died.

(*b*) 2 gave no crops.

(*c*) 10 gave white nuts only.

(*d*) 1 gave pink nuts only.

The average yield per tree is 246 nuts, of which 215 are white and 21 pink, or a ratio of 10·7 : 1, but the ratio varies in individual trees from ·2 : 1 to 897 : 1.

The mode or greatest frequency ratio occurs at 3·5 : 1. Practically every tree in this plot shows the tendency to prove the increase of the ratio of white nuts to pink mentioned above. It is impossible in the space available to reproduce the actual records of the individual trees so that the mean ratios have been incorporated in a graph (Plate XX) which shows the point in question very clearly.

For this purpose the trees have been grouped according to whether they cropped every year, every year but one, and every year but two.

This method was adopted in order to avoid the confusion which arises through trees not arriving at the peak of the curve together when, through probably external influences, they have failed to crop in one or two years.

This is clearly shown in the graph, but were the whole records graphed together, the numerous peaks for the different groups would mask the point to be emphasized.

It can be seen from a study of the figures that even in the case of trees which show yields in three scattered years, only there is a distinct tendency to this rise in ratio with a corresponding fall later.

The Trials at Aburi.

The field has six planting rows, with 12 trees in each, but only 68 trees were established. Fourteen of these are eliminated for various reasons : —

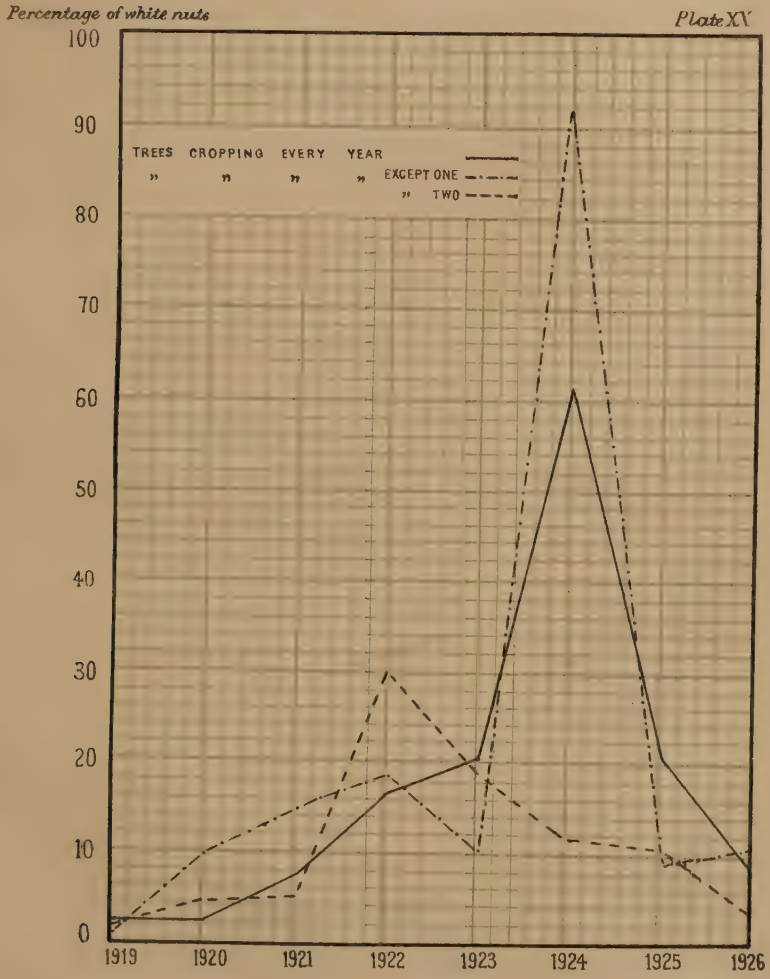
(*a*) 7 gave no crop.
(*b*) 4 gave white nuts only.
(*c*) 3 gave pink nuts only.

The same tendency as at Kibi is shown here, but as during 1921 and 1922, there was little or no crop, the graph from this station has not been considered to be worth reproduction, although it follows on the same general lines as that at Kibi. The ratio is not so wide as at Kibi and therefore the peak is not so marked, which may be accounted for possibly by differences in soil.

Since the increase in ratio of white nuts to pink appears, therefore, to be a function of age of the tree rather than a Mendelian character, it is obvious that attempting to breed a pure strain of white Cola by pollination of white by white parents would be futile. Other methods such as vegetative reproduction by cuttings and grafting will be equally useless from the fact that when a tree has reached a certain age the ratio will probably decline, no matter whether a tree is left alone or a scion taken from it and grafted into another.

It is, therefore, necessary that annual planting of white nuts be made in order that as many trees as possible may be at the peak of the curve at one time.

INDIVIDUAL COLA YIELDS AT KIBI SHOWING INCREASE OF RATIO OF WHITE NUTS TO PINK WITH AGE.



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PAPER No. XXI.

OIL PALM YIELDS ON CLEANED GROVES AT PEKI BLENGO.

By A. W. PATERSON.

The five-acre oil palm plot at Peki was in existence when the department opened this sub-station in 1913; the plot was cleared of bush and the palms cleaned during 1914 and 1915. The majority of the palms are now estimated to be 25-35 years old, and appear to be a good stand of palms. They were undoubtedly planted, but are not regularly lined out as in a plantation. Half of the plot has been thinned to 70 palms per acre, and in the other half there are fully that number to the acre.

The yields recorded from the five acres have been as follows:—

Year.	Number of bunches. (5 acres)	Weight of pericarp oil. (5 acres)
		lbs.
1916	223	544
1917	534	1,580
1918	629	2,224
1919	1,003	2,447
1920	307	801
1921	375	1,200
1922	735	2,803
1923	1,127	3,769
1924	589	2,078
1925	720	2,924
1926	428	1,653

The weight of pericarp oil has been calculated as follows:—

Fruit ... ... 50 per cent. weight of bunch.
Oil ... ... 25 per cent. weight of fruit.

The monthly distribution of bunches reaped since 1917 expressed as percentages of annual yield have been as follows:—

Months	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1917 ..	2·7	10·11	20·8	17·6	8·6	21·5	1·6	4·3	1·48	1·48	3·9	5·8
1918 ..	7·9	7·9	1·4	11·4	16·2	6·2	6·8	5·4	9·5	9·5	8·9	9·2
1919 ..	7·4	11·9	6·1	13·4	24·0	5·6	1·8	6·4	5·6	5·2	6·9	5·1
1920 ..	—	25·0	·9	—	—	23·1	2·6	4·5	21·5	5·9	8·1	8·1
1921 ..	2·9	15·4	22·1	14·9	9·9	7·7	6·4	1·86	2·4	4·2	9·07	6·1
1922 ..	11·2	14·0	9·1	16·1	10·2	8·3	8·7	5·4	4·9	7·2	3·8	1·3
1923 ..	8·3	9·5	2·6	26·4	12·06	5·7	3·5	5·4	8·4	10·1	4·4	3·6
1924 ..	7·5	35·4	12·0	18·8	—	—	8·4	6·2	7·1	2·3	1·8	—
1925 ..	1·6	12·5	15·8	13·3	25·1	8·7	1·25	—	5·3	2·9	3·0	1·6
1926 ..	12·6	14·0	10·9	17·5	11·1	—	—	—	11·1	14·4	7·9	—
Average	7·8	14·3	9·1	16·1	13·4	7·7	4·1	4·3	7·1	6·3	5·3	4·0

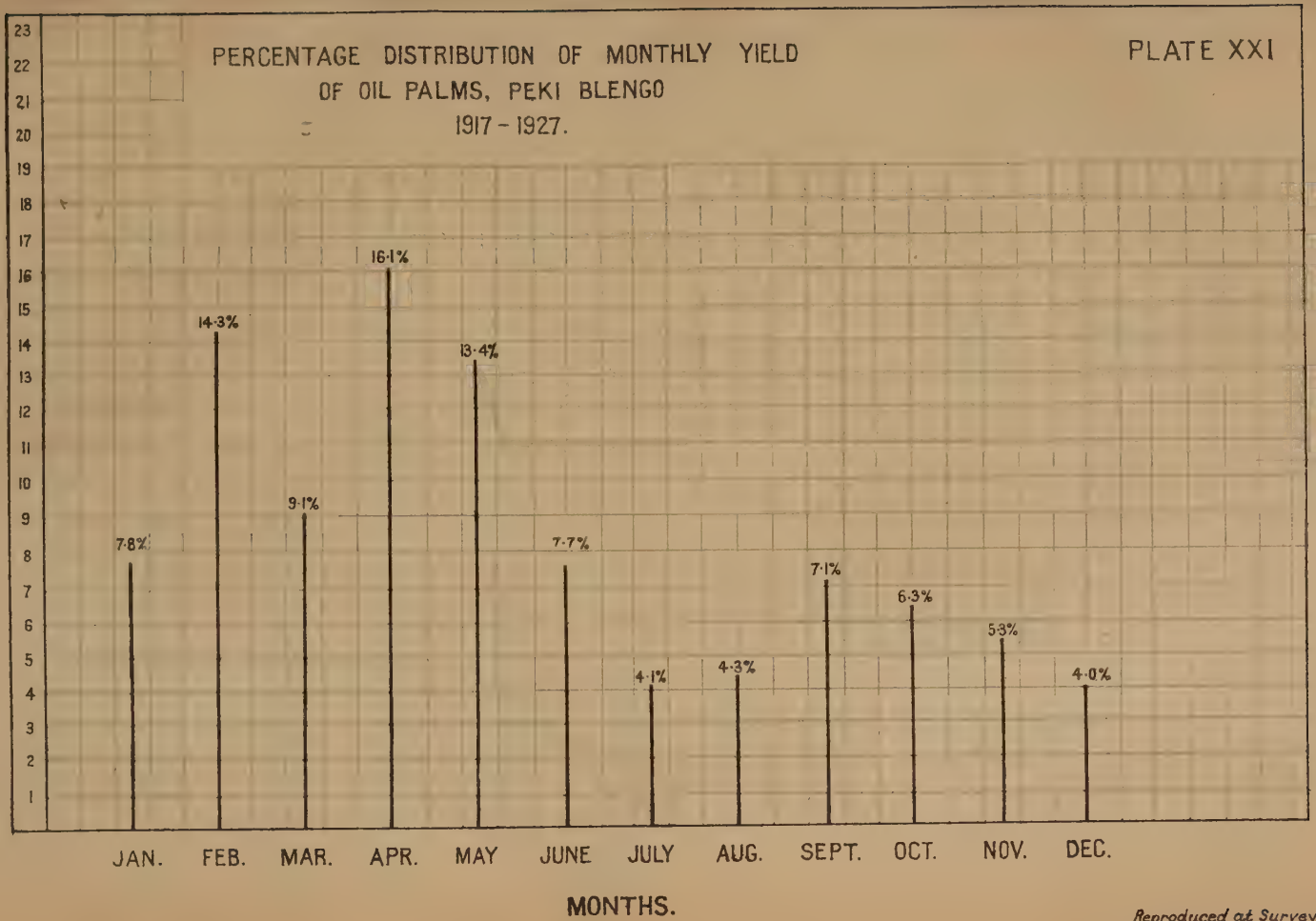
The graph (Plate XXI) shows the average monthly yields, expressed in percentages.

From this it is seen that the oil palm is in the main a two-season crop.

The main crop, which gives 39·5 per cent. of the total yield, extends from February to May and is followed by a smaller crop from September to November.

PERCENTAGE DISTRIBUTION OF MONTHLY YIELD
OF OIL PALMS, PEKI BLENGO
1917 - 1927.

PLATE XXI



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PAPER No. XXII.

ACCRA SISAL PLANTATION DURING 1926-1927.

By J. E. SYMOND, *Superintendent.*

The previous article in the Year Book for 1926 summarized the working of the plantation and factory to the end of the first half of the financial year, 1925-26. The most convenient form in which to publish a further summary of the progress of the plantation is to give in detail the results of the working year, April, 1926—March, 1927, and a brief reference to the working from April—September, 1927.

During the whole period the plantation has suffered from a very severe drought, the rainfall in 1926 being the lowest ever recorded (10 inches). This must naturally affect the replanting. A shortage of leaf has been experienced in 1927, partly due to the prolonged drought and in part to the fact that the acreage of mature sisal has been found insufficient to keep the existing factory working to capacity. Steps have been taken to increase the acreage.

Results.

The results of the working year, April, 1926—March, 1927, are shown in Appendices A and B, which give details of output and cost of production. From these it will be seen that a production of 459 tons fibre was achieved, as compared with 285 tons in the previous year. The cost of production per ton fibre was £17 6s. 7d., a substantial decrease on previous figures. As men become more efficient and production increases, a decrease has been shown in every item of production cost.

Transport charges have been materially reduced by the installation of a Fordson tractor for haulage. This machine is fitted with heavy solid double tyres and straddles the railway lines. It has proved very powerful and most efficient.

During the period, April—September, 1927, it has only been possible to work for three months, owing to the shortage of leaf. The output has been 111 tons at a cost for production of £15 12s. 2d. The results are tabulated in Appendix C. The decrease in production cost is principally due to the absence of one European under the heading "Supervision." The fibre was sold locally under a system of tenders, and market and shipboard charges are therefore eliminated.

Prices Realised.

The year, April, 1926—March, 1927, closed with a falling market, but prices realised during the period averaged £40 per ton. This is an increase on previous figures and is due to the installation of new machinery for brushing and baling, which have bettered the quality and packing of the fibre.

As the product became known on the home markets, it became possible to enter into a system of forward sales, which reduced marketing charge by some £2, by avoiding heavy landing and sampling costs.

Average shipboard and market charges were £5 10s. per ton, of which £4 16s. is for Ocean Freight. Details of the charges are as follows:—

Nature of Charge.	Cost per ton fibre.
	£
Brokers' Commission 1%	·38
Landing and sorting	·23
Port rates	·008
Rent and showing	·08
Insurance	·04
Interest on charges	·002
Petties and postages	·003
Ocean freight	4·80
	£5·543

Total revenue for the period, from fibre produced, was £14,965, as against a production expenditure of £7,954, leaving a profit of £7,011, from which to pay interest and depreciation charges. A net profit of £3,663 was realised.

Pests and Diseases.

There has been a slight recurrence of the physiological disturbance, "Sun Scorch," previously recorded. It occurs when very hot weather follows heavy rain and quickly ceases under normal conditions. Leaves affected are generally useless for decortication.

Experimental Area.

A plot of 40 acres of sisal was planted in 1925 with the object of testing the effect of reduced weeding. This plot has now received three weedings in the first two years of its life, and will not be cleaned again till after harvesting. It is healthy and well-grown and demonstrates that unless abnormal wet seasons occur, this amount of weeding is sufficient for sisal before coming into bearing.

Yield.

Percentage fibre in the leaf has remained constant at 3·4 per cent. From the commencement of harvesting to the present date, 800 acres of mature sisal have given a yield of just over 1,000 tons, equal to 25 cwts. to the acre. Poling, as usual with this crop, is very irregular, and it is as yet too early to forecast the total yield per acre.

APPENDIX A.

Accra Sisal Plantation and Factory.

SUMMARY OF PRODUCTION AND COST FOR PERIOD 1ST APRIL, 1926 TO 31ST MARCH, 1927.

Month	Number of Working Days.	Cwts. of Fibre produced.	Expenditure.
1926			£ s. d.
April	21	800	706 8 11
May	21	760	702 2 2
June	23	780	674 9 10
July	24	800	759 8 6
August	23	660	718 16 11
September	23	820	653 8 10
October	25	800	623 10 1
November	24	760	642 8 10
December	23	760	614 17 4
1927			
January	23	760	578 10 10
February	20	740	582 5 8
March	25	740	625 7 2
TOTALS	275	9,180	£7,881 15 1
Spares and Replacements not charged to any one month ..			73 0 10
Monthly average	22·91	765	£7,954 15 11

Average Output of Fibre per Working Day of 9 hours .. .. .. 33·38 cwts.

Factory and Plantation Costs of Producing 1 ton of Fibre £17 6 7

APPENDIX B.

Accra Sisal Plantation and Factory.

ANALYSIS OF PRODUCTION COSTS FOR THE PERIOD 1ST APRIL, 1926, TO 31ST MARCH, 1927.

Head of Expenditure.	Total Expenditure for 18 months.	Expenditure per ton Fibre
	£ s. d.	£
European and African Salaries, Passages and Allowances :—		
Total Supervision	1,420 0 0	3·10
Labour—Cutting leaves	1,448 16 1	3·16
,, Transporting leaves	349 9 7	·76
,, Decorticating and refuse ..	594 5 8	1·29
,, Brushing fibre	344 2 10	·76
,, Drying fibre	330 16 3	·72
,, Grading and hanking	300 7 9	·65
,, Baling, packing and marking ..	138 17 5	·30
,, Plantation roads, etc.	783 4 6	1·70
,, Stumping and clearing	162 4 6	·35
,, Engine	51 15 6	·11
,, Recruiting	273 8 3	·60
Total Labour	4,777 8 4	10·40
Total labour and supervision	6,197 12 4	13·50
Materials—Fuel, oil	534 16 9	1·17
,, Lubricants	157 5 5	·34
,, Petrol and kerosene	170 13 10	·37
,, Baling wire	44 7 6	·10
,, Baling canvas	76 5 9	·17
,, Grease and waste	9 12 8	·02
,, Miscellaneous repairs, buildings	119 16 1	·26
Extra Freight, storage and cranage ..	228 7 3	·49
,, Water	342 17 6	·74
,, Spares and replacements	73 0 10	·16
Total materials and extra	1,757 3 7	3·82
Total labour and supervision	6,197 12 4	13·50
Grand Total	£7,954 15 11	£17·32

Total Output of Fibre .. 459 tons.

APPENDIX C.

DETAIL AND COST OF PRODUCTION.

JUNE–AUGUST, 1927.

Month.	Fibre produced.	Days worked.	Expenditure.
	Cwts.		£ s. d.
June	860	26	633 0 0
July	760	25	551 19 1
August	600	22	547 14 3
	2,220	73	1,732 13 4

Average production per working day .. 30 41 cwts.
Average cost production per ton .. £15 12s. 2d.

ANALYSIS OF PRODUCTION COST.

Item.	Cost per ton.	
	£ s. d.	£
European supervision	1 11 8	1·58
Cutting leaf	3 2 1	3·10
Transporting leaf	0 14 3	·71
Decorticating	1 2 8	1·13
Brushing fibre	0 17 6	·87
Drying fibre	0 13 2	·65
Sorting and hanking	0 10 1	·50
Baling	0 4 4	·21
Plantation, roads, etc.	1 11 1	1·55
Stumping and clearing	0 6 2	·30
Engine	0 1 7	·07
Recruiting	0 12 5	·62
Overseer, headmen and office ..	0 14 0	·70
Materials :—		
Fuel oil	1 11 0	1·55
Lubricating oil	0 6 7	·32
Petrol and kerosene	0 6 5	·32
Baling wire	0 3 6	·17
Baling canvas	0 3 4	·16
Grease and water	0 0 6	·02
Miscellaneous	0 5 9	·28
Local freight	0 0 8	·03
Water charges	0 13 5	·67
	£15 12 2	£15·608

PAPER No. XXIII.

DISTRIBUTION AND YIELDS OF SHEA BUTTER-NUT TREES IN THE NORTHERN TERRITORIES.

By G. C. COULL.

The Shea butter-nut tree is botanically known as *Butyrospermum Parkii*, and belongs to the Natural Order Sapotaceæ (Dagomba *Tanga*, Hausa *kadanya*.)

Appearance of the Tree.

In the wild state, on land which shows no signs of having been cultivated, and which is swept by bush fires year after year, the tree rarely grows to a great size and is twisted and stunted; the girth is seldom more than 24 inches and the height seldom more than 20 feet. On land which is cultivated for a few years, and then reverts to bush, the tree is of greater size, and this is probably due to the few years of protection thus afforded from fire. In and around villages, where the tree is never subjected to a bush-fire, the tree grows to greater dimensions and trees up to 69 inches in girth and 50 feet in height may be seen.

The bark is deeply fissured vertically and horizontally, making square scales of great thickness. This scaling extends to quite small branches.

The leaf is from 9 ins. to 10 ins. in length, stalked, simple, entire, oblong and glabrous; the stalk taking up from $2\frac{1}{2}$ ins. to $4\frac{1}{2}$ ins.; the width is from $1\frac{1}{2}$ ins. to 3 ins. The leaves are shed each year, but the tree does not remain long without them. Leaves may be shed before, with, or after flowering and in the last instance there is no distinct period when they are without leaves.

The flowers are borne in globular corymbs, at the extremities of the branches, 2 to 3 ins. across. Sometimes flowers alone, sometimes flowers and leaves, are borne at the extremities. Each flower is creamy white, and slightly scented. Calyx 8 to 10 partite, Corolla 5 to 6 lobed. Stamens same number as or more than petals. Ovary superior, 1 to 5 celled, but commonly 1 to 2 celled; ovules solitary in each cell; fruit a berry.

The flowers are usually few in number if new leaves are produced before flowering, and a small yield of fruit is obtained. Flowers are borne from December to March. The fruit varies considerably

in size and appearance; they are round and long. The long fruit is noticeably pointed at the tip whereas the round fruits are blunt. Fruit is borne from May to August.

Natural Distribution and Habitat.

The distribution of Shea is widespread in the Protectorate. On marsh it is non-existent, and on land subject to flooding it is rarely found. The characteristic habitat is the upper slopes of the undulations which form such a noticeable feature of the country. The tree is a light-lover, and does not flourish under shade. Where such trees as *Afzelia africana*, *Isoberlinia* spp., and *Paradaniellia Oliveri* grow, it is not found. It occurs sometimes in almost pure stands of varying density.

The distribution of the tree is largely influenced by the density of the population, and by the pursuits of the people. The tree, being indigenous to the country, is found at its densest where there are neither farms nor villages. On old farmed land the trees are fewer, but larger; fewer because many have been cut out in the process of making the farm, and larger because they have been protected from the bush fires. Round the villages there are few trees, as they have been gradually cut out for timber, firewood, medicine, etc. Hence it is that, generally, the density of shea tree is inversely proportional to the population.

Pests and Diseases.

No fungoid pests have been noted. Insect pests are not numerous. A large caterpillar of *Cirina Butyrospermii* feeds on leaves and sometimes completely defoliates the tree attacked. The adult flies in May and the larva matures in September. After feeding on the trees, it pupates in a cleft at the base of the tree.

The larvæ of *Mussidia Nigrivinella* attack kernels if badly stored, but they are very easily controlled, and of no economic importance. Loranthus is prevalent in some districts, especially in the North West.

False Shea Nut Tree.

The tree *Lophira Alata*, Banks. Dipterocarpaceæ (Hausa, namijin kadai; Dagomba, kultanga), is known amongst natives as the false shea-nut. The only resemblance between this tree and the true shea-tree is in the leaves, the flowers and bark being quite dissimilar to those of *Butyrospermum.*

The *Lophira* is not common in the Northern Territories, and grows only in certain localities, usually on the banks of a river. The writer has seen specimens of this tree on the Dakar river only, where the Salaga-Krachi road crosses it.

Description of Trials at Yendi.

Investigations were started in March, 1922, when a 20-acre reservation was chosen on ground which had not been farmed, and was marked out as follows:—

SECTION A.	SECTION Z.	
7·71 acres Unweeded.	B. 3·04 acres.	C. 3·18 acres.
2·52 acres Weeded.	D. 2·72 acres.	E. 3·09 acres.

Section A was divided into a weeded and an unweeded portion and was burned. Section Z was divided into plots B, C, D and E and boundaries were fire-traced to prevent burning at the wrong time. Each plot has been burned once a year since, starting as soon after the rains as the grass was capable of being burned. Plot B is burnt first, C, D and E at successive intervals of 10 days with the idea of finding therefrom the effect of the time of burning on the yield of fruit.

Increase in Girth of Trees.

The girths of 20 trees on each of plots of A and Z were taken, and these measurements have been kept from year to year.

Girths of trees are shown in Table I.

TABLE I.

Year.	Yendi Unburned Plot.		Yendi Burned Plot.	
	Average Girth. Inches.	Increase. Inches.	Average Girth. Inches.	Increase. Inches.
1922	21·28	—	16·47	—
1923	21·36	·08	16·55	·08
1924	21·72	·36	16·90	·35
1925	22·12	·80	17·47	·57
1926	22·24	·26	17·78	·31
1927	22·38	·14	18·01	·23

In 1926, one tree died before girths were measured.

From the above figures it will be seen that the annual increase in girth is very small, and that the tree is exceeding slow-growing.

Yields of Kernels Per Acre at Yendi.

Owing to the difficulty of collecting the crop on the unweeded portion of A, and also to the fact that it was burned by some passer-by on two occasions, the yields were discontinued as being inaccurate; the weeded portion of A was kept as a control to plots B, C, D and E.

Yields of kernels are shown in the following Table II:—

TABLE II.

Plot.	Acres.	No. of Trees on Plot.	Trees per Acre.	Yields per Acre (Kernels, in Pounds).				
				1923.	1924.	1925.	1926.	1927.
A (weeded) ..	2·52	489	194	103·9	80·1	64·3	93·5	49·6
B (burned) ..	3·04	404	133	11·2	53·3	92·4	31·7	11·8
C ,, ..	3·18	473	149	39·3	29·7	75·5	37·7	13·4
D ,, ..	2·72	305	112	2·6	54·6	100·7	38·3	22·1
E ,, ..	3·09	585	189	—	17·4	44·6	21·3	15·2

From a study of Table II some useful facts are evident. The unburned, but weeded plot A consistently gave higher yields than the burned plots, except in the year 1925. As this plot was kept clear of undergrowth, no difficulty was experienced in collecting the fruit.

For the 1923 crop the burning did not begin till January. Plot C, however, was accidentally burned in December 1922, and gave the best yield. Plot E, which was in full flower when burned, gave no yield at all. It was generally considered at the time that burning was too late, and this was borne out by the yields obtained.

For the following years burning was commenced, as soon after the rains as the undergrowth was sufficiently dry to burn, which was usually the first few days in December, and continued at 10-day intervals. The greatest yield has been obtained in each case with plot D, which is burned 20 days after plot B or between the 19th and 24th December, and for the Yendi district this seems the optimum time.

Conclusions Drawn from Trials.

The conclusions drawn from these experiments are:—

(*a*) Burning should take place within 20 days after it first becomes possible.

(*b*) Premature burning increases the difficulty of collection, but the yield is good.

(*c*) Late burning, by destroying flowers, and such fruit as is set, causes practically total loss of crop.

(*d*) By the total prevention of burning, the maximum yield is obtained, but the increase in the cost of collecting the fruit would be so large as to prevent it being economically possible, apart altogether from the fact that it would be quite impracticable to prevent burning over even a small protected area.

The natives say that the shea-butter tree yields in a cycle of three years, in the sequence good, medium, poor. This has not been confirmed yet, though this sequence has been found during the first three years of the experiment.

Rainfall and Yields.

The rainfalls and yields are given in Table III.

TABLE III.

Crop-Year. (Jan.—Dec.).	Plot A. Pounds Kernels per Acre.	Rainfall.	
		For Seven Months (Jan.—July) of the Crop-Year.	For the Year (Jan.—Dec.) before the Crop Year.
1923	103·9	32·30	43·93
1924	80·1	27·66	49·68
1925	64·3	23·04	67·10
1926	95·5	23·09	46·12
1927	49·6	23·76	43·92

There seems to be no correlation between total amount of annual rainfall and total annual yield within the limits occurring during these years, but marked periodic variations in the yields occur, as is usual in permanent plants under no cultivation. A violent tornado may cause a great deal of damage by destroying fruits which have just formed.

Estimate of Supplies available.

An estimate of the potential supply of shea-butter in the Northern Territories is given in Table IV.

TABLE IV.

District.	Square Miles.	Production Area Square Miles.	Density of Shea Trees.	Average Yield Kernels per Acre	Total Yield Kernels	Amount of Kernels Used by Population.	Balance of Kernels for Export	Population.	Population for Collection Women.	Amount Capable of Collection
				Lbs.	Tons.	Tons.	Tons.			Tons.
Lawra-Tumu	3,533	2,317	51	28	18,536	3,644	14,892	82,967	11,852	8,889
Wa	3,540	3,186	41	27	25,000	1,848	23,152	42,076	11,840	8,880
Northern Mamprusi ..	2,400	480	6	94	12,877	8,457	4,420	192,510	27,501	20,626
Kussassi	790	527	8	18	4,063	2,152	1,911	49,013	7,002	5,251
Southern Mamprusi ..	2,000	1,000	61	27	7,714	557	7,157	12,774	1,825	1,369
Western Dagomba ..	4,800	4,300	63	48	58,971	3,466	55,505	78,961	11,280	8,460
Western Gonja	8,450	4,000	8	6	6,857	869	5,988	19,737	2,819	2,114
Eastern Gonja	3,800	2,600	31	24	17,828	576	17,252	13,132	1,876	1,407
TOTAL	29,313	18,410	—	—	151,846	21,569	120,277	491,170	75,995	56,996

In the above table it will be noted that the " production area " amounts to 63 per cent. of the total area of the Protectorate. The mandated area is not taken into account.

The " density of trees " is arrived at by taking the mean of counts in the various districts.

Estimates of the " Average yield of kernels " are expressed as lbs. per acre, irrespective of the number of the trees, this being regarded as more accurate than basing estimates on yields. The results from the Northern Province were determined by political officers by actual weighing, but in the Dagomba and the two Gonja Districts the figures were calculated from the results obtained from the Yendi trials.

"Amount of kernels consumed," and " Balance for export," are determined by assuming that a family of five consumes $10\frac{1}{4}$ lbs. of shea-butter per month, and 25 per cent. of butter is obtained from the kernels.

" Population available for collection " is based on the assumption that the number of able-bodied women is one-seventh that of the total population. The Commissioner of the Wa District, however, supplied the figures for his District, which include all females over six years of age.

The " amount capable of collection " is obtained on the assumption that one woman in a season of 90 days will collect 15 cwts. of kernels. The reason is given below. It will be noted that the women of Kussassi and Northern Mamprusi, whilst capable of collecting 5,251 and 20,626 tons of kernels respectively, have only 1,911 and 4,420 tons to collect.

Figures are not available to the exact volume of existing exports of shea-butter to Ashanti and the Colony. Assuming, however, that it is equal to the internal consumption, the balance available for export is 98,708 tons of kernels. As, however, native methods only yield 25 per cent. of butter, whereas by extracting by solvents 50 per cent. could be obtained, it will be seen that the existing local need would be met by half these quantities were a factory established in the Protectorate, and the fat available for export would be 65,138 tons per annum. With the existing native methods, however, the balance would be 98,709 tons of kernels or 24,677 tons of fat.

DIFFICULTIES OF CENTRALISATION.

The harvesting of the crop under the existing distribution of the population must be now considered. At present the industry is entirely in the hands of the women, and if the figures for available women are correct, the total amount of kernels that could be collected would be 56,996 tons. (This is calculated as follows:— The fruiting season lasts from the middle of June to the end of September—say 90 days. Each woman collects a load of

60 pounds of fruit per day, a total for 90 days of 15 cwts. of kernels). From this total of 56,990 must be taken 3,340 tons and 16,206 tons on account of Kussassi and Northern Mamprusi Districts respectively, leaving under present conditions 40,450 tons of kernels to be collected by the villagers scattered throughout the whole of the Protectorate.

On account of the sparse distribution of the trees, women have in many cases to go long distances from their villages to get the fruits, and at present they merely collect enough for making shea-butter for their own use, and for supplying itinerant traders.

A trading firm in Kumasi sent a representative here during the past season to buy kernels, and offered 1s. 3d. per tinful (equal to £5 per ton of kernels), and could get only a few tons. Itinerant traders are able to pay prices much in excess of the market value on the spot, and yet makes good profits in Ashanti and the Colony. The price in Kumasi is usually three times that in Tamale.

As time is of no object to a native, he always thinks of the value of shea-kernels as being that of the price of the shea-butter capable of being extracted therefrom. A kerosene tinful of kernels, weighing 27 lbs., therefore, would be valued at 7 lbs. of shea-butter, which is about the amount capable of being extracted by their own methods.

The fact that the industry is entirely in the hands of the women is against it, and men cannot be induced to go out and collect the fruits.

SUMMARY.

Summarising this report we see that:—

(*a*) The present production is entirely in the hands of the women, and this is probably a great factor against the establishment of an industry in kernels.

(*b*) Added to this, we have the fact that the native, time being no object to him, would like the same price for the kernels as the price of the fat extracted from the kernels.

(*c*) The estimated crop of kernels used is 21,569 tons kernels, and the estimated export as the same amount, making a total of 43,138 tons of kernels used annually.

(*d*) The annual yield could be increased by careful control of burning, but as the densest areas are away from villages, this is exceedingly difficult.

(*e*) The amount, 40,450 tons of kernels, capable of being collected, would be scattered throughout the whole of the Protectorate.

(*f*) The potential supply is 120,277 tons of kernels, and it is quite evident that large quantities go to waste each year.

PAPER No. XXIV.

PREPARATION OF LEAF COMPOST AS A MANURE FOR THE DENUDED SOILS OF ACCRA.

By C. H. KNOWLES and J. M. DUNBAR.

The land which forms the residential area of Accra was originally of exactly the same character as what is known as the Accra plains—being covered with coarse grass and shrubs with here and there a few stunted trees.

The real soil is thin and not rich, vegetable matter being destroyed by fires, which in the plains generally are of annual occurrence. In a natural state, the soil has reached a condition of balance, its quality being just sufficient to maintain the coating of grass and shrubs.

When the land was taken for building purposes, the grass, shrubs and trees were cleared away. Lines of ornamental trees were used as an edging for the bungalow sites and roads were constructed. Drainage was confined to the sides of most of the roads.

When the bungalows were occupied, the development of the compounds was a matter for the occupants. Dhoub grass was planted in many compounds and at first thrived, but unless regularly watered this grass died out completely.

LOSS BY DENUDATION.

From the time the original clearing was made, the soil has been subjected to regular denudation. Every shower of rain washes away some of the soil, and the daily sweeping up of fallen leaves by the sanitary gangs is responsible for much more serious denudation. In one compound of approximately one acre in 1926 over 400 cubic feet of fallen leaves were collected in eight months. Normally this would have been destroyed by sanitary gangs, but actually the experiment was tried of using it as manure and it was buried in garden beds. When it is remembered that the soil was poor to start with, it is not surprising to find that under a few years of unrestrained tropical showers and the organised efforts of sanitary gangs, the surface soil is entirely removed and the raw sub-soil exposed. This is quite unsuited for grass,

PLATE XXII.

COMPOST SHED IN ACCRA.

hedges, shrubs and flowers, and needs special preparation to fit it for garden purposes. This preparation consists of adding to the soil organic matter in the form of humus.

Primarily when humus was required the only way to get it was to leave heaps of vegetable matter on the garden to decay—a process objected to by the Sanitary Authorities—or the sweepings of the garden were used at once, not a very effective method as the decay is slower.

PREPARATION OF COMPOST.

Mention has been made of the very considerable quantity of vegetable matter obtained every year from a compound, and up to the present all this has usually been burnt and so entirely wasted.

In order to facilitate the use of this material in the soil and to prevent the waste, a special building was erected at the Accra Horticultural Nursery for the purpose of converting it into humus. The sanitary side of the question—the breeding of flies, etc.—had of course to be considered and the only alternative was a fly-proof building. The building which has been erected is a trial one and if it is successful similar buildings can be constructed at the major stations of the Department.

The building consists of a concrete tank 12 ft. by 12 ft. by 3 ft., surmounted by walls 10 feet high of mosquito proof gauze covered over by a roof of wood and felt. The floor is concrete with a slight fall towards the door of the building draining into a sump measuring 3 feet cube. A photograph of the building is given (Plate XXII) showing tank, mosquito proof meshing, sump and cover, etc. Part of the finished compost of the last charge can be seen outside the building.

The principle of the compost heap is the decomposition of vegetable matter to which has been added soil and lime. The method adopted here for charging the compost tank is as follows: First, a layer of refuse is put in, this is covered with a thin layer of soil on top of which is placed a very thin layer of lime. This procedure is repeated until a height of about three feet has been reached, and the whole is then covered over with a fairly thick layer of soil. Water is added until the whole charge is moist, which condition should be maintained throughout the period of decomposition.

It has been found that the watering, which is done about once a week, can be satisfactorily carried out with a hose. The drainage from the sump is returned from time to time to the material in the tank. From three to four months is required for the process of decomposition depending upon the kind of material employed. After being allowed to decay for two or three months, the heap should be turned over. Each charge of the tank provides about 10 tons of valuable manure (432 cubic feet at approximately 55 lbs. per cubic foot).

FUTURE TRIALS.

A supply of Standard Adco has been ordered in order to speed up the process of decomposition. Adco is a fine powder which embodies late scientific discoveries. Its function is to create the ideal conditions which cause the useful bacteria to work and also to increase the amount of plant nutrients. An article on the value of this synthetic preparation appeared in " The Tropical Agriculturist," Vol. LXVII., No. 6, December, 1926.

Organic matter has been long recognised as an important constituent of soil; it breaks up stiff clays, gives cohesion to sandy soils and increases moisture-holding capacity. It also provides valuable food material to plants. Its use as an addition to the impoverished soils of compounds in Accra is absolutely essential to enable such soils to be used for ordinary garden purposes.

For the best effects the humus should form part of the whole depth of soil likely to be reached by plants in the garden bed.

PAPER No. XXV.

METHODS OF SOIL SAMPLING AND SOIL ANALYSIS RECOMMENDED PROVISIONALLY FOR USE IN WEST AFRICA.

Following is the report submitted to the West African Agricultural Conference by the Chemical Committee of the Conference. The Departmental Chemists forming the Committee were: DR. F. J. MARTIN *and* Mr. H. C. DOYNE *of the Sierra-Leone Department;* Messrs. A. C. BARNES, C. H. WRIGHT *and* E. DE B. DIAMOND *of the Nigerian Department;* CAPTAIN R. COULL *of the Gold Coast Department.—(Editor.)*

The Committee took the methods put forward by Messrs. F. J. Martin and H. C. Doyne (Sierra-Leone Department) as a basis for their discussions and the following methods of sampling and examining soils were recommended for provisional use, the whole question to be reviewed at the next West African Agricultural Conference.

2. Determinations Necessary for Soil Characterisation.

The Committee discussed the question as to what determinations were necessary for characterising the soil type. It was thought that certain determinations were essential in soil analysis, but that others, although very desirable, could not always be carried out owing to lack of time. It was decided therefore to agree as to what determinations were essential and to leave the chemist on the spot to supplement these by whatever additional determinations he thought necessary.

It was agreed that when examining soils for the purpose of soil survey the following determinations were necessary:—

(1) Mechanical analysis (including amount of calcium carbonate where present).

(2) Organic carbon in first foot.

(3) Acidity or alkalinity expressed as pH values.

(4) Total nitrogen on soil types.

(5) Analysis of the clay fraction of definite soil types. This analysis to include determination of silica, alumina, iron and combined water.

Other determinations, such as soluble salts, lime requirement, phosphate, potassium, nitrate, etc., yield valuable information, but for the time being are not included in the list of essential data. It should be left to the discretion of the chemist to decide what determinations are required to supplement those given in 1—5 above.

3. Methods of Sampling.

It was decided that the instructions with respect to sampling given in the Appendix of the paper, should be circulated for the information and use of the agricultural and forest officers who might be interested in taking and submitting samples. It was realised, however, that a certain amount of latitude should be allowed in the taking of samples and that where suitable conditions prevail—*i.e.*, the soil is not too stony, hard or sandy— and suitable tools are available, there is no reason why such tools should not be used. All that is necessary is to ensure that the section is vertical and that the sample does not include more from one horizontal layer than another. There is, however, one advantage in digging the actual holes, and that is the digging can be done by a native and the soil profile down to four feet is fully exposed, and this often yields valuable information. It was agreed that photographic records of soil profiles should be taken where possible.

4. Classification of Soil Particles.

As a preliminary to discussing mechanical analysis the classification of soil particles was considered. It was thought that within limits the number of soil separates should be kept as low as possible. The classification considered as a basis of discussion had the objection that it did not correspond with that recommended by the Committee of the Agricultural Education Association, but by very small alterations it was made to do so.

The classification recommended is as follows:—

A. "Stones and gravel"—all particles greater than 1 mm.

B. "Fine earth"—all particles less than 1 mm.

All further mechanical and chemical analysis are made on, and expressed as percentage of, the "fine earth."

The fine earth is divided into the following fractions:—

Coarse sand less than than 1 mm. but greater than ·2 mm. in diameter.

Fine sand less than ·2 mm. but greater than ·04 mm. in diameter.

Silt less than ·04 mm. but greater than ·002 mm. in diameter.

Clay less than ·002 mm.

If the silt should form a large proportion of the "fine earth" and it should be considered necessary to separate this fraction further, then the following fractions are recommended:—

Coarse silt between ·04 and ·01 mms.

Fine silt between ·01 and ·002 mms.

5. Methods of Mechanical Analysis.

It was decided to carry out mechanical analysis by the beaker method of sedimentation, as this was the more suitable method for native assistants to use*. Further, that all determinations should be made on the oven dry (105° C.) soil, as in West Africa the moisture in air-dry soil varies greatly from the wet to the dry season, there being a big difference between the relative humidity of the atmosphere during these seasons.

(*a*) *Preliminary Acid Treatment.*—It was decided that preliminary acid treatment, where necessary, should be used to bring the method into line with that recommended by the Committee of the Agricultural Education Association. Actually, none of the chemists in West Africa had yet found a soil containing appreciable quantities of calcium carbonate.

(*b*) *Treatment with Hydrogen Peroxide.*—This was thought unnecessary owing to the low humus content of the soils, the instability of hydrogen peroxide in the tropics, and the undue lengthening of the process of mechanical analysis.

(*c*) *Deflocculator.*—Either ammonia or sodium carbonate.

(*d*) *Method of Extracting Fractions.*—The fractions to be expressed on an "ignited" basis, but the clay fraction to be expressed both "oven dry" and ignited. This conclusion was reached in view of the fact that the Agricultural Education Association Committee recommended the "ignited" basis, but Dr. Martin produced evidence, recently obtained, to show that the "ignited" basis might involve considerable error, especially with lateritic soils which are common in West Africa.

(*e*) *Loss on Ignition.*—This determination still to be made on a separate 1 mm. sample.

(*f*) All results to be recorded as percentages on the "oven dry" soil.

6. Organic Carbon.

The following methods were considered suitable:—

(*a*) *Dry combustion.*—Total carbon is determined as follows:—

A weighed portion of soil (about two grams) is ignited in a combustion tube in a current of carbon dioxide free air and the carbon dioxide given off, after passing over heated copper oxide and through a drying column, is collected in potash bulbs and weighed. This gives accurately the amount of carbon in the soil.

The apparatus found most efficient is an electric tube furnace such as is made by Messrs. Gallenkamp & Son. It is clean, does not heat the

*Note.—This does not exclude the use of depth concentration methods (*e.g.*, Robinson's method) when the analyses are carried out by a competent chemist.

room unduly, and the temperature of the various parts of the tube can easily be controlled. With this apparatus, half-a-dozen determinations can easily be made during the day.

Inorganic Carbon.—Can be determined either by the Schrotter apparatus or by means of the following method. A flask of 300 c.c. capacity is fitted with a stopper through which passes a dropping funnel and a glass tube. The glass tube connects with two tubes containing fused calcium chloride and then passes into potash bulbs containing a fifty per cent. solution of potassium hydroxide. After the potash bulbs comes a small U tube containing solid potash and another containing fused calcium chloride. A weighed quantity of soil is placed in the flask with a little water, dilute sulphuric acid is run slowly on to the soil through the dropping funnel. The rate of evolution of the carbon dioxide should be about two bubbles a second as it passes the potash bulbs. When the evolution of the gas has ceased the remainder of the acid is run in and the flask gently heated. A current of air is drawn through the apparatus by means of an aspirator, the mouth of the dropping funnel being guarded by a small soda-lime tube.

Organic Carbon.—The organic carbon is determined by subtracting the inorganic carbon from the total carbon.

In Sierra Leone soils there is practically no inorganic carbon and the soil is acid. Where this, on testing, is found to be the case, the figure for total carbon can be taken as organic carbon. This simplifies the analyses considerably.

(*b*) *Method described by Sir Francis Watts in the West Indian Bulletin, Vol.* 12, 1912, *page* 70 :—

About two grammes of very finely powdered soil, or as much as may be expected to yield about 90 to 100 c.c. of gas are placed in a small flask of about 50 c.c. capacity having a side tube in the neck. (Wurtz flask.) To this, 10 c.c. of concentrated sulphuric acid are added and mixed by gently shaking. The flask is now attached, by means of the side tube and a piece of stout rubber tubing, to a suitable apparatus for measuring gas described below. When first attached the flask is brought into such a position that the neck is horizontal, a platinum boat containing chromic anhydride is placed in the neck, and the neck closed by means of a rubber stopper, care being taken that the neck is not soiled during the introduction of the chromic anhydride, so as to ensure that none comes in contact with the rubber stopper. While in this position, the apparatus is allowed to assume the temperature of the air; when this is accomplished, the gas-measuring apparatus is adjusted.

The gas-measuring apparatus consists of a nitrometer with a three-way cock connected with a reservoir of mercury and a manometer tube. To adjust the apparatus, the nitrometer is filled with mercury by raising the mercury reservoir while the nitrometer is in communication with the outside air through the appropriate channel of the stop-cock. The flask is now also brought into communication with the outside air by means of the stock-cock: thus the contents of the entire apparatus are at atmospheric pressure. The flask is now brought into communication with the measuring apparatus, by a proper turn of the stop-cock. The flask is then brought into a vertical position whereby the chromic anhydride falls into the flash; this is brought into intimate contact with the soil and acid in the flask by gently shaking, whereupon gas is at once given off. The flask is now immersed in a bath of boiling water to complete the reaction, and is agitated occasionally; in about twenty minutes the evolution of gas ceases, the hot water bath is removed, the apparatus allowed to resume the temperature of the air, the mercury levels in the measuring apparatus accurately adjusted and the volume of gas evolved measured. This volume is simply that found in the measuring apparatus, and is independent of that contained in the flask and its connections, which remains constant.

From the volume of the gas evolved after correction for temperature and pressure, the weight of carbon is easily calculated.

7. Acidity or Alkalinity (pH).

The Committee thought that this might be determined either electrometrically or colorimetrically at the discretion of the chemist. Where colorimetric determinations were made they should be checked in a few instances by electrometric determinations. The Committee also thought that no good purpose would be served by tying down the chemist to a particular method to be followed when making pH determinations, but they considered that the strength of the soil/water extract or suspension warranted consideration when determining hydrogen-ion concentration.

As a general rule it was agreed that a soil/water ratio of 1/5 was suitable and that the time of extraction should be one hour. It was pointed out, however, that a soil/water ratio of 1/5 was not always suitable and the case of Sierra Leone soils was instanced. Here a 1/5 extract indicated a nearly neutral or only faintly acid soil, while 1/1 extract indicated a distinctly acid soil which was corroborated by a high "lime requirement." The Committee therefore agreed that while 1/5 soil to water ratio might be regarded suitable concentration, yet if the pH values yielded by other concentrations indicated that the 1/5 extract was giving unreliable results, adaptations of the proportions of soil to water should be made at the discretion of the chemist carrying out the examination.

Preparation of Soil Suspension or Extract.—The determining of the method of preparing the soil suspension or extract for testing is a matter of considerable difficulty. These difficulties are discussed by Joseph and Martin (*Journal of Agricultural Science,* Vol. 13, p. 321), and for Sudan soil the proportions of soil to water was fixed at one to five, and the time allowed for extracting as one hour. In Sierra Leone we get results more easily by using one part soil to one part of water, and in this connection it must be remembered that the salt and the clay content are both much lower in Sierra Leone soils. In using the colorimetric method in Sierra Leone we take twenty grams soil, add twenty grams of water and shake—allow to stand for one hour and then centrifuge in a small hand centrifuge about 1,500 r.p.m. for five minutes. Almost invariably the supernatant liquid is quite clear. Ten cubic centimetres of this liquid is poured into a standard size glass tube, the indicator added and compared with standards.

8. Total Nitrogen.

The Committee agreed to adopt the Kjeldahl method, but recommended steam distillation as a method of overcoming difficulties of spraying.

Nitrogen.—In soil survey work which involves the sampling of various places on only one occasion, it is quite unnecessary to determine ammonia or nitrates, and total nitrogen is the only nitrogen determination which need be carried out.

9. Analysis of the Clay Fraction.

Here again, the Committee thought it advisable to tie the hands of the chemist. This analysis involves fusion of the clay with a fusion mixture and the subsequent estimation of silica, iron, alumina and "combined water." In so far as the estimation of silica,

iron and alumina is a purely chemical problem any of the accepted methods are probably satisfactory. The Committee thought that the combined water might be estimated as the "loss on ignition," less the organic matter present, the organic matter present being determined as in paragraph 6 above.

10. Soluble Salts.

The Committee thought that the methods described in the following paragraphs are suitable:—

Total Soluble Salts.—Here again the chief difficulty is to determine the proportions of soil and water and the length of time the extraction is to be allowed to last. Very convenient proportions are one part soil to five parts water, this being allowed to stand twenty-four hours, and it is suggested that this method of extraction be adopted.

Filtering.—In some cases there is a difficulty in securing a clear solution, this is not usually so with acid soils, but in cases where a clear filtrate cannot be obtained by ordinary filter paper, it can generally be obtained by filtering through a thin film of collodion. To prepare this take a Buchner funnel and stick a filter paper on to the floor of the filter by means of rubber solution applied round the edges of the filter paper. After this is dry run a solution of collodion on to the filter paper till the surface is covered (quickly pour off any excess), allow to dry slightly, and then wash with water. Fix into a filter pump, and it is ready for use. Do not let the collodion film get dry, or it will be ruined. Filter with the aid of an ordinary filter pump.

The whole filtrate or an aliquot part is then evaporated down to dryness, giving the amount of total salts, and the analysis of the dry salt thus obtained can be carried out in the ordinary way.

Electrical Resistance Method.—A quick way of determining the total salts is by means of the resistance of the solution to an electric current. A platinum cell consisting of two platinum plates covered with platinum black are used and the constant of the cell is determined by measuring the resistance of the cell when immersed in a solution of potassium chloride of known strength. The constant of the cell being known, the resistance of the soil solution is measured by dipping the cell into the soil solution and taking a reading. The specific resistance of the solution is the observed resistance cell constant. An approximation of the salts in the solution can then be obtained by calculation. A closer approximation can be obtained by plotting a curve showing the relation between the concentration of soil salt and the resistance, and referring resistances of soil solutions to this curve, corrections being made for temperature.

By the electrical method fifty determinations can be made in an hour, and if not strictly accurate, they are at least comparable.

11. Summary.

In general, the Committee held that some standardisation of sampling, classification and analysis was necessary in order to ensure that the essential minimum of trustworthy data for characterisation and comparison of soil was rendered available. The Committee have indicated in paragraph 2 what determinations, in their opinion, constitute this essential minimum and for the benefit of the agricultural chemist in the various Colonies they have described suitable methods by which this data may be obtained. The Committee was of the opinion that, subject to the necessity for producing results on a comparable basis, the chemist should be given as free a hand as possible.

Appendix.

INSTRUCTIONS FOR SOIL SAMPLING.

Soil sampling should be carried out by the trench, as no special implements are required and the same method therefore can be adopted all over the Colony and Protectorate.

Selection of Site for Sampling.—The areas sampled should be typical of the district, or if two or three types of soil exist in the same district each should be sampled. Single samples are not very much good, as qualities of the soil, not obvious to the eye, may vary, and opinions based on single samples be very misleading.

It will be left to the discretion of the officer in charge of the district as to which sites he thinks would give the most valuable information. Of course, a comprehensive survey like the above may take two or three years to complete, depending on the opportunities the officer has for visiting the various parts of his Province, but a start should be made at once.

Taking the Sample.—A hole or trench should be dug to the depth of four feet; generally about four by two is a suitable size. When the hole has been dug the side should be freshly scraped before taking the sample; a spade or basket should then be held pressed against the trench exactly one foot from the surface of the hole and a slice of earth of even thickness scraped from the side of the trench and caught in the basket; care should be taken that this should be an even slice from the top of the hole down to the bottom of the first foot. The soil so taken should be broken down into small lumps, thoroughly mixed and a sample about 1½ lb. placed in the sample bags provided. The bag should be clearly marked in indelible pencil or ink on top with the place, the number of the hole and then the depth from which the sample is taken, *e.g.*—

$$\frac{\text{N'jala}}{\frac{3}{2}}$$

would mean that the sample was taken in a district near N'jala, it was the third hole dug and the sample was from the second foot.

All four feet should be sampled as described above.

Samples may be sent in as taken. It is not necessary to sample a whole Province before sending in the samples from the first few holes.

Information to be sent with samples:—

1. The position of each hole should be indicated as clearly as possible, *i.e.*, chiefdom, district, miles from nearest town or village.

2. Type of country, *e.g.*, forest, grassland, arable, etc.

3. Crops or trees growing on land, especially noting any dominant weeds.

4. General information, such as stony or clay soil, drains easily or badly, good or bad crops growing.

5. Topographical—hilly, undulating, flat, marshy, etc.

PAPER No. XXVI.

METEOROLOGICAL RECORDS OF THE GOLD COAST FOR 1927.

COMPILED BY N. P. CHAMNEY AND J. M. ADAMS.

During the year under consideration there have been a large number of requests sent to the Department for information as to data other than rainfall, and it has been considered, therefore, that the scope of this paper should be enlarged to cover all records taken at the stations.

The Bulletin No. 2 of the Department on the Rainfall of the Gold Coast has been in great demand both locally and in other countries, and it is proposed to revise this shortly to include all meteorological data, and thereby widen the scope of its utility.

Stations.

There are no stations of the first or second orders established at present in the Gold Coast, but there are fourteen of the class known as Auxiliary Climatological Stations which rank as third order stations of the International Classification.

Of these two only, Kumasi and Accra are fitted with barometers, but Accra has, in addition, barograph, thermograph, anemometer and a Campbell Stokes sunshine recorder.

Observations are taken daily at all these stations at 9 o'clock G.M.T.

In addition, there are 53 stations where rainfall records only are taken.

Kpedsu, where records have been kept up to 1926, was closed down during the year.

New stations opened this year are: Bole, Kpeve and Akropong.

Records were recommenced at Gambaga and Goaso.

Rainfall Tables.

The monthly rainfall at each station during 1927 are given in Table II, and in addition the highest and lowest rainfalls recorded in previous years for each station.

Unusual figures have been recorded at Essuasu, 102·63 in. in 105 days, and the monthly figures at Half Assini 23·44 in. in

17 days, Axim 22·61 in. in 27 days, Atuabo 20·02 in. in 14 days, all in June, and Mpraeso 20·02 in. in 20 days, and Juaso 21·71 in. in 22 days, both in October, are worthy of note. On the whole, it may be stated that the rainfall was less than that of 1926, but the extremes at each end of the tables approach more nearly.

A notable fact is that the highest rainfall on any one day, 4·78 ins., was recorded at Accra on May 13th.

In the Rainfall Map for 1927 have been included not only the stations where records are now being kept, but also records from stations where records have ceased to be taken and also some of those from the old German stations in Togoland. It must be understood that these maps are based on the average rainfall of each station up to and including the year named. It is interesting to note that with inclusion of stations around the range of hills stretching from Mampong to Aburi, the coincidence of rainfall to the physiography of the country becomes more marked.

Degrees of Wetness.

These figures are given in Table I, and show in one, the total rainfall and the distribution of the precipitation.

They are obtained by the formula:

$$\frac{R \times D}{100}$$

where R = total rainfall and D the wet days.

This gives a more accurate idea of the prevailing moisture conditions in relation to agriculture than does the mere statement of total rainfall.

Temperatures.

The average monthly figures for the maximum and minimum temperatures in the shade, together with other data, are set out in Table III.

On reference to this Table, it will be seen that the greatest range of temperature is experienced at Akuse, closely followed by Kintampo and Tamale, while Aburi registers little difference between maximum and minimum.

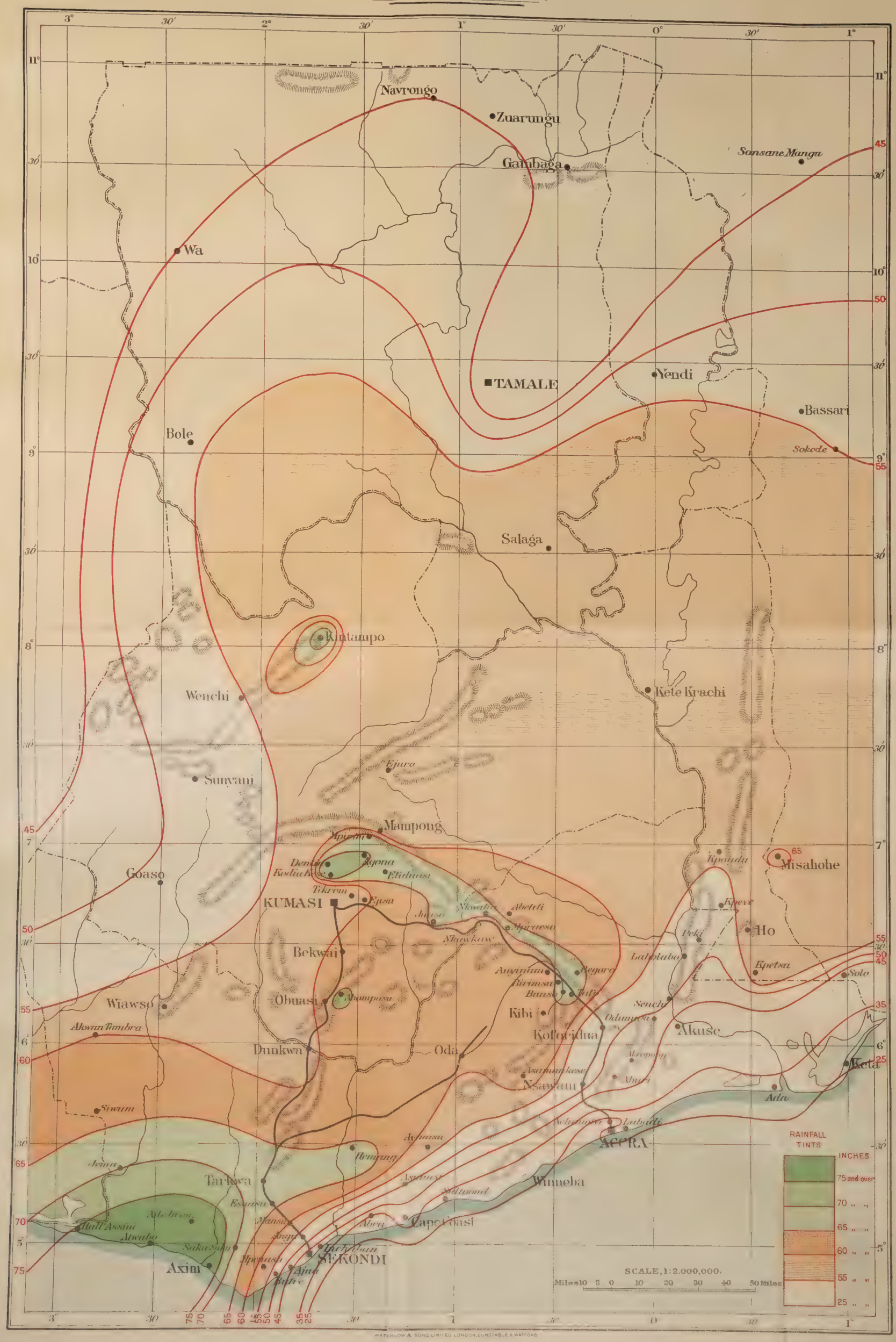
The highest temperature recorded during the year was 115° at Kintampo in June 25th, but in nine months out of the twelve, Tamale recorded the highest figures, which ranged between 99° and 109°.

The lowest temperature in the shade was 49° at Kumasi, on January 12th, but Kintampo had the lowest figures for nine months of the year, with figures of 50°-51°.

— PLATE Nº XXIII. —

DEPARTMENT OF AGRICULTURE.

Mean Distribution of Rainfall (to the end of 1927).



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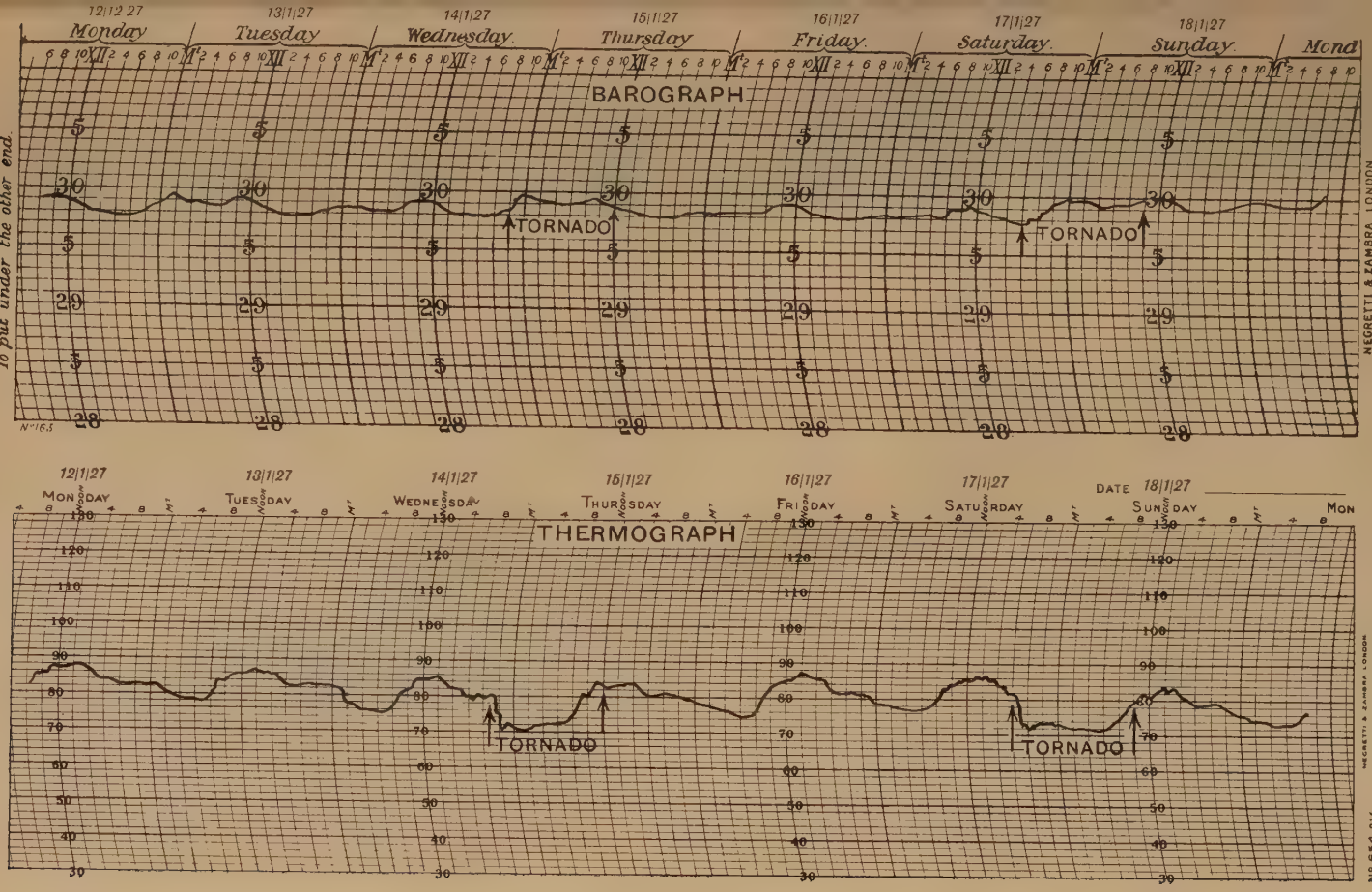
LIST OF RECORDING STATIONS.

Name.	Amount Inches.	No. of years of record.
Abetifi	(42.99)	10 months
Abompasu ...	66.95	6 years
Abra	32.56	6 „
Aburi	47.79	37 „
Accra	27.43	41 „
Achimota	24.54	3 „
Ada	32.05	7 „
Adeja	70.65	1 „
Adebrem	68.46	3 „
Agona	72.12	2 „
Ajua	44.91	8 „
Akropong	(29.01)	10 months
Akuse	41.09	13 years
Akwantambra ...	60.00	—
Angu	51.27	2 „
Anyinam	65.80	21 „
Asamankese ...	61.73	5 „
Asromaso	68.36	1 „
Asuansi	50.07	19 „
Asumenya ...	(34.88)	6 months
Atwabo	79.02	1 year
Axim	76.29	13 years
Ayinasu	55.17	7 „
Begoro	68.17	6 „
Bekwai	63.51	14 „
Birimsu	70.45	13 „
Bole	(54.62)	10 months
Bunso	68.86	8 years
Butre (Seysie) ...	50.36	7 „
Cape Coast ...	40.10	6 „
Dentin	—	—
Dunkwa	56.20	13 „
Efiduasi	66.16	1 year
Ejisu	60.68	2 years
Ejura	59.23	12 „
Esuasu	88.00	2 „
Gambaga	44.63	3 „
Goaso	50.90	4 „
Half-Assini ...	77.18	6 „
Hemang	67.08	10 „
Ho	56.26	6 „
Inchaban	41.38	1 year
Jema	70.00	—
Juaso	65.48	12 years
Keta	26.66	22 „
Kete Kratchi ...	49.03	9 „
Kibi	64.96	15 „
Kintampo... ...	70.75	13 „
Kodia Kese ...	73.53	2 „
Koforidua... ...	51.30	6 „
Kpetsu	52.38	4 „
Kpeve	(49.80)	10 months
Kumasi	58.50	21 years
Labadi	25.34	5 „
Labolabo	50.81	8 „
Mampong	56.23	2 „
Mansu	59.92	14 „
Mpenasa	58.07	3 „
Mpirim	66.98	2 „
Mpraeso	67.78	10 „
Navrongo	45.56	2 „
Nkawkaw ...	64.59	2 „
Nkwatia	65.00	10 „
Nsawam	52.20	2 „
Obuasi	62.03	4 „
Oda	60.19	13 „
Odumasi	44.14	3 „
Peki Blengo ...	52.09	13 „
Salaga	51.57	13 „
Saltpond	31.27	13 „
Sekondi	40.18	24 „
Senchi	40.00	—
Siwum (Dadiasu)...	64.74	6 „
Suku Suku ...	70.00	—
Sunyani	53.61	13 „
Tafo	62.11	2 „
Tamale	42.22	18 „
Tarkwa	68.42	24 „
Tikrom	57.42	2 „
Wa...	45.62	11 „
Wenchi	54.88	6 „
Wiawso	56.99	12 „
Winneba	27.91	7 „
Yendi	53.98	6 „
Zuarungu	43.37	10 „

GERMAN FIGURES.

Bassari	51.2
Kpandu	54.6
Misahohe	68.8
Sansane Mangu ...	42.2
Sokode	55.6
Solo	42.9

PLATE XXIV.


12|12 27
Monday
13|1|27
Tuesday
14|1|27
Wednesday.
15|1|27
Thursday
16|1|27
Friday.
17|1|27
Saturday.
18|1|27
Sunday.
Mond
BAROGRAPH
TORNADO
TORNADO
To put under the other end.
NEGRETTI & ZAMBRA LONDON
12|1|27
MONDAY
13|1|27
TUESDAY
14|1|27
WEDNESDAY
15|1|27
THURSDAY
16|1|27
FRIDAY
17|1|27
SATURDAY
DATE 18|1|27
SUNDAY
MON
THERMOGRAPH
TORNADO
TORNADO
NEGRETTI & ZAMBRA, LONDON

The range of shade temperatures gives an idea of the relative heat of the district concerned, and it is found that the coastal belt, as recorded at Accra, Achimota, Axim, Sekondi, and Keta, shows small range of temperature, due to the cooling sea-breezes, and the maximum ranges are found in the open savannah of the North and Togoland, as recorded by Kintampo, Tamale and Akuse.

The maximum Solar radiation occurs always at Tamale, and has reached, this year, a figure of 175° on two occasions.

Relative Humidity.

This figure, obtained by calculation from the difference of the readings of the Hygrometers (wet and dry bulb), is found to be highest in the forest area and lowest in the open country.

Asuansi, Aburi, Tarkwa, Begoro are all of the order of 80 per cent. or over, while the northern stations rarely exceed 70 per cent.

During the Harmattan the relative humidity drops very quickly; an actual record of a drop of 65 per cent. (from 85 per cent. to 20 per cent.) in two days having been noted in January at Accra. A corresponding rise occurs at the finish of the Harmattan.

Isotherms.

An Isothermic map has been prepared, but space does not allow of its inclusion in the present paper. It suffices to say that the Isotherms follow the general configuration of the country, and have their axes in the South-West corner of the Colony. They rise steeply on the far side of the arc of mountains running from Kumasi to Aburi, and reach the maximum at the Tamale-Akuse line, whence a slow fall occurs towards the French frontier of Togoland.

Barometer Readings.

Barometers are only employed at Accra and Kumasi, and are therefore of local interest only. A barograph is installed at Accra and a specimen chart of one week's readings is found on Plate XXIV, fig 1. A Thermograph chart for the same period is found on Plate XXIV, fig. 2, as showing the influence of the storms recorded on January 14th and January 17th. It will be noted that as the storm approached, a rise in the barometer was coincident with a sharp fall in temperature. The reverse process is noted on the departure of the storm area. The barograph shows slightly the depression which takes place in pressure as the centre of the storm approaches.

It is evident that in neither case, however, did the exact centre of the storm pass overhead or the depression would most certainly have been more marked. It serves, however, to show the value of the instruments in the study of storms and climatology generally.

Phenology.

The science of phenology or the relation of weather to crops is in its infancy on the Gold Coast, but a start has been made on the correlation of cacao yields and rainfall in Paper 12 of this Year-book.

It is hoped, during 1928, to make further studies of these correlations, which undoubtedly are important as a factor in forecasting the yields of crops. In the Paper mentioned above, the rainfall during April has an evident relation to the following crop of cacao, and it is fairly certain that other factors may be found to influence the yields of other crops.

A severe Harmattan will check plants to cause such loss of leaf that the season's crop may be seriously diminished.

Lack of rain or unsuitable distribution causes dropping of flowers and consequent loss of crop, while excessive rain or prolonged distribution affects the sun drying of cacao or coffee and results in a loss of quality.

Lack of knowledge of the meteorology of a district may therefore well cause failure of an attempt to establish an agricultural industry, and for that reason alone is of importance to any one connected with agriculture in any of its branches.

TABLE I.
Degrees of Wetness 1927.

Kibi	119
Abompasu, Axim	116
Esuasu	108
Adeja	101
Hemang	100
Tarkwa	97
Juaso	94
Agona	93
Half Assini	92
Wiawso	91
Atwabo, Goaso	83
Begoro, Siwum	78
Dunkwa, Mpraeso, Mpirim	77
Kintampo, Kumasi	75
Tafo	70
Oda, Effiduase, Anyinam	69
Seysie (Butre), Asromaso	67
Asamankese, Koforidua	63
Aburi, Salaga	59
Kpeve	58
Kodia Kese, Ejisu	57
Asuansi	53
Tikrom	50
Wenchi	49
Nkawkaw	48
Bole	47
Bekwai, Mpenassa, Angu	45
Ejura, Mampong	44
Sekondi	43
Sunyani, Yendi, Kete Kratchi	42
Peki Blengo, Wa	41
Ajua	39
Gambaga	38
Mansu, Tamale	35
Odumase, Nsawam	33
Zuarungu	31
Akuse	29
Asuminya	25
Akropong	20
Abra	16
Accra	15
Keta, Achimota	11
Labadi	8
Saltpond	7

TABLE II.

Summary of Rainfall in inches for all Stations in the Gold Coast for the Year 1927.

MONTH.	1 Essuasu (2 years).	2 Half-Assini (6 years).	3 Atuabo (1 year).	4 Agona (2 years).	5 Juaso (12 years).	6 Axim (13 years).	7 Hemang. (10 years).	8 Wiawso (12 years).	9 Adeja (1 year).	10 Mpraeso (10 years).	11 Abompasu (6 years).	12 Nkawkaw (2 years).	13 Asromaso (2 years).	14 Anyinam (21 years).	15 Kibi (15 years).	16 Mpirim (2 years).
January	2·73	0·89	0·83	0·21	0·60	0·80	0·15	0·42	0·84	1·12	0·25	1·00	Nil	0·92	1·75	0·20
February	2·25	1·86	0·68	1·27	0·62	4·32	3·88	1·49	1·76	0·56	3·45	1·05	0·75	1·31	3·13	3·20
March	10·12	7·58	3·22	4·96	7·33	6·73	13·77	4·63	6·58	2·56	3·22	2·80	3·44	5·12	9·35	5·78
April	7·56	7·22	9·83	9·49	6·16	1·77	9·67	12·35	10·91	5·66	8·10	5·20	5·87	4·70	6·97	9·13
May	10·55	12·53	10·59	7·38	6·51	12·48	12·15	9·49	9·56	5·78	5·58	5·31	5·52	10·99	7·34	11·19
June	12·71	23·44	20·02	11·72	11·11	22·61	7·50	11·59	4·51	6·56	7·79	9·45	7·29	8·49	9·28	8·84
July	2·17	4·25	3·13	4·80	2·51	1·87	2·87	6·54	4·06	8·52	5·12	5·50	4·18	3·72	3·45	3·30
August	Nil	0·30	0·05	3·89	1·18	0·42	1·29	0·39	1·32	2·22	2·15	2·00	1·95	3·03	0·93	0·99
September	13·72	5·10	2·80	13·88	12·51	0·73	4·27	8·53	12·23	13·73	12·87	14·85	8·22	9·36	9·93	10·67
October	18·80	3·09	11·26	12·02	21·71	7·37	10·13	11·50	15·05	20·02	13·65	15·40	15·47	14·77	6·02	10·36
November	18·50	10·02	6·32	5·14	4·38	8·04	5·36	4·78	2·45	2·99	4·90	3·95	2·31	3·44	3·50	0·76
December	3·52	5·67	10·29	1·89	1·20	6·87	2·89	1·43	1·38	0·87	3·11	2·00	0·36	1·75	5·73	2·40
TOTAL ..	102·63	81·95	79·02	77·10	76·12	74·01	73·93	73·14	70·65	70·59	70·19	68·51	68·36	67·60	67·38	66·82
Number of Rainy Days (·01 inch or more) ..	105	112	105	121	123	157	136	125	143	109	166	70	98	102	176	115
Highest previous Rainfall	—	88·77	—	—	75·19	109·65	85·86	70·44	—	85·26	67·39	—	—	95·07	79·90	67·14
Lowest previous Rainfall	73·38	61·63	—	67·15	53·42	47·64	47·04	40·14	—	57·55	65·18	60·68	23·23	40·27	45·77	—

TABLE II.—*continued*

Summary of Rainfall in inches for all Stations in the Gold Coast for the Year 1927.

Month.	17 Effiduase (2 years).	18 Dunkwa (13 years).	19 Siwum (Dadiasu) (6 years).	20 Tarkwa (24 years).	21 Tafo (2 years).	22 Kodia-Kese (2 years).	23 Salaga (13 years).	24 Begoro (6 years).	25 Kumasi (21 years).	26 Goaso (4 years).	27 Asamankese (5 years).	28 Kintampo. (13 years).	29 Ejisu. (2 years).	30 Oda (13 years).	31 Tikrom (2 years).	32 Nsawam (2 years).
January	0·05	0·59	1·50	2·67	0·61	0·50	0·34	0·53	0·23	0·44	1·52	Nil	1·23	0·81	0·48	2·59
February	1·51	1·02	0·97	2·35	2·43	4·35	0·51	5·12	1·17	1·62	1·98	2·20	1·09	1·79	1·24	1·81
March	3·60	2·97	2·62	7·34	5·42	4·44	0·14	5·57	6·27	2·51	7·67	1·07	5·64	5·76	4·17	3·97
April	6·60	7·78	8·92	5·09	4·38	6·99	6·55	7·92	9·93	6·10	5·63	6·01	10·23	4·33	8·29	3·42
May	6·29	8·91	7·20	8·74	6·28	4·23	7·08	8·11	3·69	9·20	6·43	11·81	5·13	6·39	5·80	10·89
June	7·98	8·54	12·36	10·91	12·32	5·45	8·48	6·64	4·95	5·63	5·13	11·25	6·20	4·62	5·50	5·13
July	6·00	4·18	5·28	1·49	5·01	6·49	6·07	3·61	3·70	2·56	6·44	6·46	4·78	1·92	4·92	2·95
August	1·17	0·80	1·17	0·09	1·11	0·83	5·61	1·18	0·38	3·52	1·11	1·67	0·85	1·31	1·06	Nil
September	16·31	6·16	8·03	3·94	6·50	12·54	14·33	5·75	11·59	8·62	4·28	8·82	9·08	5·51	7·00	3·58
October	13·89	14·15	14·73	11·34	10·98	12·56	9·59	10·81	15·51	13·67	6·60	8·15	11·94	7·88	14·49	7·91
November	0·67	4·70	2·49	6·17	4·51	2·96	1·88	1·77	2·23	4·59	4·37	1·12	0·37	7·12	0·48	4·45
December	2·09	6·18	0·63	3·43	3·28	0·20	Nil	3·29	0·57	1·04	7·61	Nil	0·26	8·63	2·05	8·70
Total ..	66·16	65·90	65·90	63·56	62·83	61·53	60·58	60·30	60·22	59·50	58·77	58·56	56·90	55·97	55·48	55·40
Number of Rainy Days (·01 inch or more) ..	105	117	118	153	111	93	98	129	124	139	108	128	100	123	91	59
Highest previous Rainfall	—	77·91	73·62	95·03	—	85·83	64·52	72·86	70·40	50·79	77·47	100·58	64·45	83·75	59·37	—
Lowest previous Rainfall	24·03	45·55	70·61	48·22	61·39	—	37·79	50·43	40·07	44·94	51·43	48·87	—	43·61	—	49·01

TABLE II—*continued.*

Summary of Rainfall in inches for all Stations in the Gold Coast for the Year 1927.

MONTH.	33 Koforidua (6 years).	34 Mpenassa (3 years).	35 Wa (11 years).	36 Bole (10 months).	37 Wenchi (6 years).	38 Angu (2 years).	39 Ejura (12 years).	40 Mampong (Ash.) (2 years).	41 Seysie (7 years).	42 Kpeve (10 months).	43 Bekwai (14 years).	44 Peki Blengo. (13 years).	45 Sunyani (13 years).	46 Aburi (37 years).	47 Mansu (14 years).	48 Kete-Kratchi (9 years).
January	0·29	1·80	Nil	—	Nil	0·53	1·02	Nil	1·68	—	0·18	Nil	Nil	2·01	0·70	3·70
February	1·72	5·73	0·28	—	3·35	1·15	2·30	1·10	3·36	—	2·38	0·90	1·34	2·48	0·75	0·66
March	1·70	4·46	Nil	0·03	2·87	6·44	2·84	3·65	4·06	4·31	5·41	4·74	2·27	6·40	3·50	1·12
April	9·61	3·32	4·68	9·62	8·57	2·98	10·04	5·80	3·28	4·44	10·78	5·79	6·44	5·51	3·45	4·42
May	6·27	8·21	12·33	6·87	6·30	11·23	4·55	11·22	12·76	5·33	5·35	9·07	5·31	3·47	7·05	6·45
June	7·10	13·04	6·54	10·33	4·01	11·44	7·29	7·89	11·90	5·91	6·16	4·59	6·81	3·81	8·75	11·95
July	3·61	2·50	7·07	7·82	5·12	1·25	4·67	Nil	1·45	5·10	1·74	3·32	1·48	3·00	1·00	2·99
August	0·40	0·55	7·57	4·20	2·94	0·57	0·12	0·31	0·27	0·52	0·10	2·54	1·67	0·52	Nil	1·34
September	6·53	4·75	7·86	9·18	5·77	3·73	7·44	9·54	3·52	9·99	6·60	4·68	9·71	2·96	2·85	5·74
October	7·31	5·47	7·80	5·97	11·44	7·26	9·47	10·02	5·48	9·56	6·72	7·30	11·95	5·55	9·05	5·11
November	2·97	2·70	0·60	0·60	3·03	2·41	1·57	1·57	2·28	2·11	2·83	3·23	0·85	4·08	4·40	1·10
December	7·62	2·46	Nil	Nil	Nil	3·96	0·40	1·61	1·72	2·53	1·26	2·48	0·50	8·02	5·40	1·50
TOTAL ..	55·13	54·99	54·73	54·62	53·40	52·95	52·71	52·51	51·76	49·80	49·51	48·64	48·33	47·81	46·90	46·08
Number of Rainy Days (·01 inch or more) ..	114	82	75	86	91	86	83	84	129	117	91	84	87	123	75	91
Highest previous Rainfall	53·97	60·27	50·71	—	60·95	—	80·75	59·96	58·96	—	104·90	68·46	69·47	73·16	83·70	60·41
Lowest previous Rainfall	51·78	58·96	29·08	—	58·25	49·58	47·45	—	58·30	—	46·21	36·33	41·30	32·09	54·46	43·61

TABLE II—*continued.*

Summary of Rainfall in inches for all Stations in the Gold Coast for the Year 1927.

Month.	49 Akuse (13 years).	50 Sekondi (24 years).	51 Yendi (6 years).	52 Zuarungu (10 years).	53 Gambaga (3 years).	54 Odumase (3 years).	55 Tamale (18 years).	56 Asuansi (19 years).	57 Ajua (8 years).	58 Keta (22 years).	59 Asuminya (6 months).	60 Akropong (10 months).	61 Achimota (3 years).	62 Abra (6 years).	63 Accra (41 years).	64 Labadi (5 years).	65 Saltpond (13 years).
January	0·68	0·56	0·43	Nil	Nil	0·08	Nil	0·08	0·41	0·04	—	—	0·45	Nil	0·50	Nil	Nil
February	2·68	4·54	0·95	Nil	0·10	2·33	1·50	3·40	2·61	5·63	—	—	5·10	4·93	3·87	3·81	0·45
March	4·11	2·63	0·27	Nil	0·15	3·89	Nil	3·18	1·68	1·77	—	2·05	1·54	2·14	1·88	2·42	2·55
April	5·70	5·09	3·37	2·02	0·68	6·40	6·58	6·86	3·38	6·07	—	2·73	2·19	2·64	1·40	0·56	3·82
May	3·35	7·73	5·72	4·32	3·95	2·96	3·04	2·95	7·93	6·55	—	4·09	2·98	3·99	6·60	5·71	4·43
June	6·65	11·81	8·12	8·46	6·03	4·12	10·18	5·28	8·09	8·80	—	4·96	2·68	3·89	2·10	1·62	1·75
July	3·27	1·88	4·90	8·09	8·55	2·99	2·62	0·91	1·52	Nil	5·87	1·03	Nil	0·26	0·39	0·78	Nil
August	Nil	Nil	3·68	6·54	5·30	Nil	7·42	2·22	0·27	0·42	1·98	Nil	Nil	Nil	0·04	Nil	Nil
September	5·15	3·46	8·52	9·11	11·40	4·40	5·44	2·07	2·89	0·06	10·54	4·24	Nil	0·55	0·13	0·05	0·35
October	8·90	2·12	6·39	4·12	3·98	9·23	4·81	4·59	3·95	1·96	12·61	5·77	2·84	2·16	1·48	2·22	0·40
November	2·00	2·28	1·57	0·92	0·73	2·09	0·18	7·72	2·43	2·69	3·46	Nil	5·83	2·15	1·16	1·37	2·79
December	2·97	3·03	Nil	Nil	Nil	3·91	Nil	1·96	2·81	2·45	0·42	4·14	4·93	2·49	5·29	5·68	3·59
Total ..	45·46	45·13	43·92	43·58	42·87	42·40	41·77	39·22	37·97	36·44	34·88	29·01	28·54	25·20	24·84	24·22	19·73
Number of Rainy Days (·01 inch or more) ..	64	97	96	71	88	78	85	136	104	31	73	68	41	65	60	35	36
Highest previous Rainfall	58·98	57·76	67·12	51·62	56·47	49·77	61·77	74·17	49·03	51·44	—	—	24·09	34·18	44·20	36·87	43·80
Lowest previous Rainfall	35·14	32·98	46·12	37·93	34·75	43·43	32·36	35·62	36·81	13·88	—	—	21·00	27·28	10·84	10·78	24·38

TABLE III.

Temperature Records for the Year ending 31st December, 1927.

Month.	Keta.			Tamale.			Tarkwa.			Sekondi.			Accra.			Kumasi.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
January ..	85·5	75·4	80·4	96·6	59·0	77·8	88·7	66·3	77·5	87·8	70·5	79·1	87·1	72·4	79·7	88·7	60·5	74·6
February ..	90·6	77·0	83·8	100·5	67·4	83·9	93·1	71·7	82·4	88·2	74·9	81·5	86·7	75·7	81·2	91·9	69·3	80·6
March	84·0	75·2	79·6	103·7	71·8	87·7	93·0	71·5	82·2	88·0	75·7	81·8	87·3	76·2	81·7	90·8	71·9	81·3
April	83·4	73·8	78·6	96·6	70·9	83·7	92·0	71·5	81·7	87·5	75·1	81·3	86·6	75·3	80·9	88·7	70·8	79·7
May	87·0	80·7	83·8	94·1	69·7	81·9	92·1	71·8	81·9	87·8	75·2	81·5	85·6	75·7	80·6	88·6	70·3	79·4
June	86·3	81·3	83·8	88·8	68·1	78·4	88·4	67·8	78·1	83·6	73·2	78·4	84·3	74·1	79·2	85·6	70·8	78·2
July	86·9	77·5	82·2	87·1	68·0	77·6	89·5	69·6	79·5	81·9	71·5	76·7	80·3	73·1	76·7	82·3	69·7	76·0
August ..	82·1	75·3	78·7	86·5	67·4	76·9	84·9	68·2	76·5	80·6	70·6	75·6	78·6	70·9	74·7	81·3	68·6	74·9
September ..	84·7	74·9	79·8	88·1	66·8	77·4	85·2	70·7	77·9	81·4	72·4	76·9	80·0	73·4	76·7	82·5	70·1	76·3
October ..	85·5	77·1	81·3	91·3	67·1	79·2	89·5	71·2	80·3	85·2	72·5	78·8	85·0	74·5	79·7	86·8	70·0	78·4
November ..	83·5	75·7	79·6	96·9	63·0	80·1	91·2	70·2	80·7	88·5	73·3	80·9	87·0	75·3	81·1	91·1	71·0	81·0
December ..	85·8	76·1	80·9	98·6	59·8	79·3	80·7	71·6	76·1	88·6	75·3	81·9	87·0	75·7	81·3	90·8	70·4	80·6
Mean	85·6	76·6	81·0	94·0	66·6	80·3	89·1	70·2	79·6	85·7	73·3	79·5	84·6	74·3	79·4	87·4	69·3	78·3

TABLE III—*continued.*

Temperature Records for the Year ending 31st December, 1927.

Month.	Asuansi.			Aburi.			Kintampo.			Axim.			Akuse.			Begoro.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
January ..	87·5	68·0	77·7	87·7	70·1	78·9	94·1	64·0	79·0	84·8	68·8	76·8	94·2	60·6	77·4	94·1	66·7	75·4
February ..	89·5	70·9	79·7	89·0	71·3	80·1	98·4	64·9	81·6	86·2	73·9	80·0	96·3	65·5	80·9	94·0	63·3	78·6
March	89·0	71·2	80·1	89·2	71·8	80·5	98·1	63·8	80·9	86·4	72·6	79·5	96·6	65·7	81·1	93·9	65·1	79·5
April	88·4	72·1	80·2	88·1	70·9	79·5	92·0	64·1	78·0	86·1	70·9	78·5	94·5	65·7	80·1	91·6	64·3	77·9
May	87·9	71·7	79·8	88·4	71·7	80·0	91·1	64·1	77·6	85·9	72·1	79·0	95·7	64·4	80·0	89·2	65·4	77·3
June	83 6	70·5	77·0	84·9	69·4	77·1	86·9	63·2	75·0	82·1	70·9	76·5	92·3	61·6	76·9	86·4	65·8	76·1
July	82·5	70·5	76·5	81·6	67·9	74·7	84·5	66·6	75·5	79·5	71·3	76·2	88·5	59·9	74·2	85·0	65·3	75·1
August ..	81·3	68·9	75·1	81·6	66·6	74·1	84·9	65·2	75·0	80·2	70·3	74·9	90·9	59·2	75·0	81·1	66·1	73·6
September ..	81·8	71·3	76·5	82·0	68·2	75·1	85·8	68·9	77·3	82·2	71·0	75·6	89·9	59·8	74·8	81·7	67·9	74·8
October ..	84·8	71·2	78·0	84·1	70·0	77·0	87·6	66·7	77·1	84·6	71·7	76·9	91·9	60·8	76·3	84·4	67·9	76·1
November ..	85·4	69·9	77·6	85·0	70·8	77·9	91·7	66·0	78·8	81·2	71·3	77·9	93·9	60·4	77·1	87·7	68·4	77·8
December ..	86·3	70·8	78·5	85·4	71·7	78·5	93·6	62·8	78·2	85·6	72·9	79·2	86·9	60·0	77·4	87·2	67·9	77·5
Mean	85·6	70·6	78·1	85·6	70·0	77·8	90·4	65·0	77·8	83·7	71·4	77·6	92·6	61·9	77·2	87·2	66·2	76·6

TABLE III—*continued*

Relative Humidity, 1927.

Month.	Asuansi.	Axim.	Aburi.	Tarkwa.	Begoro.	Kumasi.	Sekondi.	Accra.	Akuse.	Keta.	Kintampo	Tamale.
January	83·3	86·5	66·3	86·2	79·7	78·5	77·8	66·0	67·2	73·5	51·0	66·8
February ..	86·0	86·1	84·9	85·9	80·8	80·3	81·9	76·5	67·8	72·6	59·3	68·9
March	86·5	81·7	82·0	83·5	83·8	82·5	79·7	73·5	65·9	72·2	66·7	50·7
April	86·8	85·5	85·1	86·1	82·9	84·8	81·0	75·0	74·3	72·3	72·2	63·0
May	87·0	84·9	85·0	81·0	84·9	83·8	80·7	68·4	74·1	72·2	73·0	67·0
June	87·7	89·7	84·3	85·7	87·5	87·7	84·5	77·6	78·8	71·0	78·4	76·7
July	91·5	85·8	89·7	84·5	88·6	84·4	82·9	80·6	74·9	66·2	75·5	77·9
August	91·9	87·9	88·5	84·2	90·6	85·8	84·7	78·2	64·2	79·3	76·5	76·8
September ..	92·4	89·7	91·3	89·2	91·4	88·2	86·2	78·7	68·3	63·8	81·1	79·6
October	88·2	89·9	88·1	86·1	85·4	86·3	83·7	71·1	73·9	70·1	75·4	73·5
November ..	88·0	83·6	90·3	85·9	81·9	83·0	79·7	73·3	72·4	73·0	67·8	56·3
December ..	89·5	87·4	91·0	88·5	80·7	86·5	81·1	79·4	77·2	62·7	71·8	42·4
Mean	88·2	86·6	85·5	85·5	84·8	84·3	81·9	74·9	71·5	70·7	70·5	66·5